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THE

ECHINODERMATA

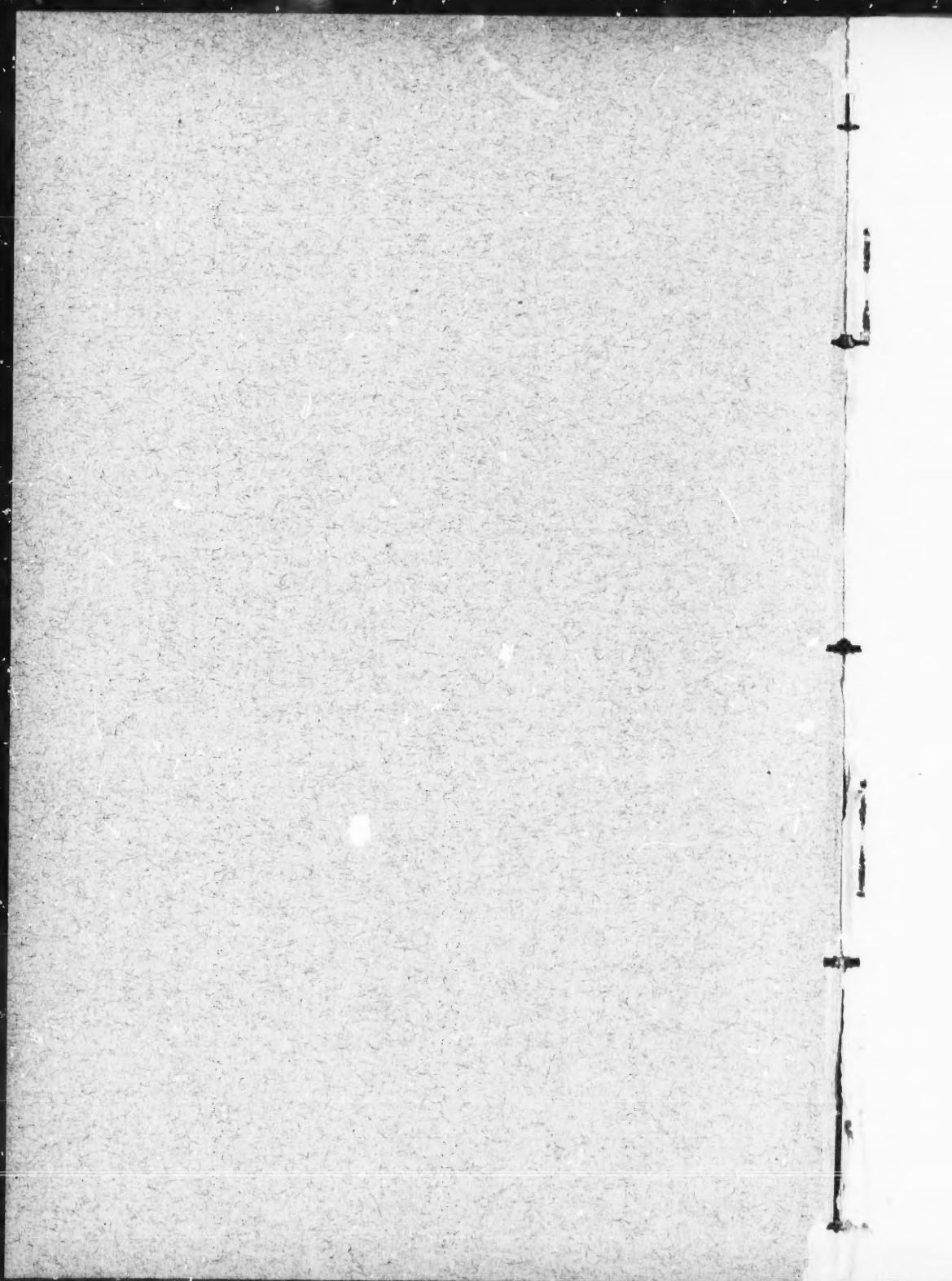
OF

NEW BRUNSWICK.

BY
W. F. GANONG.

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ARTICLE I.

THE ECHINODERMATA OF NEW BRUNSWICK.

BY W. F. GANONG.

I. INTRODUCTORY.

The Echinodermata have always been to naturalists among the most interesting of Invertebrates. Among the first of the reasons for this is undoubtedly the abundance of hard parts in the group in general, and the constancy with which they indicate specific differences. Indeed, in most of the Echinoderms, the hard parts of the body bear a closer relation to the internal anatomy and are more immediately correlated and connected with it than in any other group of Invertebrates, with the possible exception of the Insects. Again, the comparative ease with which they may in general be collected, preserved and prepared for study, the prominence given to many of them among shore animals by their symmetrical forms, bright colors and conspicuous habitat, the comparative simplicity of their gross anatomy and ease with which they may usually be dissected, the clearness with which they illustrated the old "radiate" type of animal-structure and its relation to other types, as well as important general structural features,—all these, together with the very interesting problems connected with their development and their relation to extinct forms, have caused them to receive a large share of attention from naturalists of all ages, both professional and amateur.

The mere idler by the sea-shore, if he notices animals at all, notices these among the first. Bright in color many of them, symmetrical in form all of them, often abundant and

easily found, with powers of slow but easily-watched locomotion, they attract more attention than the duller-colored and more sluggish, though more useful Mollusca, or the more active and shy Crustacea.

To the teacher there is no group of marine animals which can be made of greater use for teaching purposes. Not only are they interesting for the reasons we have already mentioned, but simply as objects of practical study they possess many advantages. Many of them are easily collected and preserved, and prepared specimens may be made to show more of the internal anatomy than is possible with any other group. Their comparative simplicity of structure and abundance of supporting hard parts make many of them better subjects for dissection than the Mollusca or Crustacea, and their larger size gives them an advantage over the Insecta. They are particularly well adapted, too, for the illustration of many general zoological principles. The habits of the shore forms can be quite easily watched and studied, either upon the shore (which is the best way), or in glass vessels in the school-room. Many simple and harmless experiments may be tried upon them which will teach most valuable lessons, not about Echinodermata alone, but about animal life in general. The mind of a pupil wisely led to observe forms as low as these, will be grasping, though altogether unconsciously, a truer perception of what Nature really is, and a broader sympathy with her workings in the world about him. Seeing in these simple creatures, so different from what he has been accustomed to associate with the name animal, characteristics in common with the higher animals, including himself, he must in his mind link closer together what before seemed far apart, must include in one category what before seemed different in kind, and thus will come a step nearer to that conception, grand and ennobling when fully grasped, the true basis of all scientific knowledge,—the fundamental unity of Nature.

That the proper kind of study of animals and plants affords the best means that we have of arousing and exercising powers of observation and inductive reasoning, is too

well known to require repetition. But teachers should not forget that before they can make use of this means towards the much to be desired end, they must be trained in these respects themselves. To those who live within reach of the sea-shore, the group we are considering is a particularly good one for self-training. Those who may take up the study can have the additional stimulus of knowing that they may at any time add to science a substantial contribution. Problems are waiting everywhere for solution, and many of them are within the reach of any patient and accurate observer. Almost nothing is known of the habits of even our most common Echinoderms, not enough to give us any clear idea as to what features of their environment their very peculiar structure is adapted. We cannot doubt that the ten rays of *Solaster*, or the five of *Cribrella*, or the spine-clusters of *Crossaster*, or the marginal web of *Pteraster*, are as exquisitely adapted to some conditions of those animals' lives as is the structure of a flower to cross-fertilization by Insects.

No one of the Echinoderms of our coast has any special economic value. Doubtless this fact explains why they have been so little noticed by those early writers who treated of the natural history of the Province. Early works which have chapters on the Mammals, Birds, Reptiles and Fishes, quite ignore this group, though mentioning the edible Mollusca and Crustacea. The earliest reference to the Echinoderms of this region is found in "Les Voyages du Sieur de Champlain," written by Champlain himself and published at Paris in 1613. He mentions the occurrence of Sea-urchins in 1604 on Saint Croix (now Dochet or Neutral) Island; "Autour de notre habitation il y a de basse mer quantité de coquillages, comme coques, moules, ourcins & bregaux qui faisoient grand bien a chacun." Lescarbot and Denys seem to make no mention of the group, though the latter wrote a book on the natural history of this part of Canada. No work seems to contain any reference to them up to Cooney's "History of Northern New Brunswick and Gaspé," in 1832, which mentions among the "shell-fish" of the Province, the Starfish and Sea-urchin. Rev. C. Atkinson, in 1844, mentions

the Starfish and Sea-spider ; the latter is the name by which *Gorgoncephalus Agassizii*, or the Basket-fish, is known to the fishermen, and it may have been to it he referred, or it may have been to some species of crab. Gesner, in his "Industrial Resources of Nova Scotia," in 1849, gives among the "marine and fresh water fishes of Nova Scotia, New Brunswick and Prince Edward Island," *Asterias rubens*, *Starfish*, but no others. Neither Perley nor Adams, in their writings on our Zoology, mention any of the Echinodermata.

The first paper by a naturalist, dealing with this region, is by William Stimpson (afterwards Dr. Stimpson), in the Proceedings of the Boston Society of Natural History, Vol. IV., 1851, (B).* In it he describes before the Society the results of a visit to Eastport, mentions the Invertebrates he found there, and gives brief notes upon several species of Echinoderms. He noticed the northern character of the fauna of this region, and seems to have been the first to have done so. He explained it by the depth of the water and the mixing up by the strong tides of the colder bottom with the warmer surface water, the temperature of which could therefore never become high. The prevalence of fogs, too, he thought kept the sun's heat from exerting its full power upon the water. Three years later, in 1854, the same naturalist published the most important work which has yet appeared on the Invertebrates of New Brunswick, his "Synopsis of the Marine Invertebrata of Grand Manan: or the Region about the Mouth of the Bay of Fundy, New Brunswick," (D). Dr. Stimpson spent three months of the summer of 1852 dredging around Grand Manan, finding there many new species of Invertebrates. In the Synopsis he mentions twenty-five good species of Echinoderms, three of them new. This work is an annotated list, giving descriptions of new species only.

In 1861, Mr. C. B. Fuller published in the Proceedings of the Portland Natural History Society (G), some notes on the Invertebrates of Eastport Harbor, and in 1863, in the second report on the Natural History and Geology of the State of

* See the Bibliography following.

Maine, a much longer list (H), containing references to many Echinoderms found at Eastport and in the Saint Croix River.

In 1866, Professor A. E. Verrill published a very valuable paper entitled,—“On the Polyps and Echinoderms of New England, with Descriptions of new Species,” (L). This corrects the synonymy up to date, and gives the range and habitat of every Echinoderm then known upon our coast. In 1871, a short paper by the same author in the Bulletin of the Essex Institute (N), referred to the Invertebrates found in the vicinity of Eastport and the character of the life in the different channels among the neighboring islands. It gives us quite a complete list of the Echinoderms of Eastport Harbor.

In 1872, an exploring expedition of the United States Fish Commission had its headquarters at Eastport, and thoroughly examined the waters of the vicinity. The general results were published by Professor Verrill in a series of articles in the American Journal of Science (R), and scattered through them are a few references to the Echinodermata. They are, however, more important for the knowledge they give us of the depths, temperatures, tides, etc., of the region,—in a word, of its physiography. A complete report, embodying the results of his seven years' work in the Bay of Fundy, is promised us by Professor Verrill. This will describe some new species and add to the Bay of Fundy fauna several not described in the following pages. Professor Verrill also refers frequently in his report on the Invertebrate animals of Vineyard Sound (Q), to the fauna of the Bay of Fundy. Nothing more seems to have been done upon the southern coast, until the writer in a short paper (X), read before this Society and published in its Bulletin No. IV., together with a note in Bulletin No. V., gave the result of some desultory observations of his own upon the littoral and shallow-water forms of the inlets of the Charlotte County coast.

So much for the Bay of Fundy waters. Our knowledge of the Echinoderm fauna of the “North Shore” is very scanty indeed, and what we have we owe entirely to the observations of Mr. J. F. Whiteaves of the Canadian Geological Survey.

Sir William Dawson, over thirty years ago, was acquainted with the littoral fauna of the southern part of the Gulf, but he never published anything upon it. During the summers of 1871-72-73, Mr. Whiteaves dredged in the deeper, and to a limited extent in the shallower parts of the Gulf of St. Lawrence, but was able to give but little attention to the latter. From our whole North Shore, excluding for reasons presently to appear the deeper parts of the Gulf of St. Lawrence and its outliers, Orphan and Bradelle Banks, we have recorded only eight or nine species of Echinoderms. It must, however, be remembered that the shoal and sandy character of the region is not favorable for an abundance of this group, which prefers rather deep and rocky situations. Mr. Whiteaves' results, including much valuable material on the physiography of the region, were published in a series of papers (P), which will be found described in the Bibliography. We wish very much to have filled this gap in our knowledge of the Invertebrate Zoology of the Province, and any of our teachers who may live upon the North Shore will be rendering to it a real service if they will help to make known to this Society what species are to be found upon the shores and in the shallow waters of the Gulf of St. Lawrence. There is work of this kind to be done, too, upon the Bay of Fundy coast, for we know nothing of the distribution of forms beyond Charlotte County. How far up the Bay any of them extend we do not know.

In the coast waters of New Brunswick, as limited in this paper (no fresh-water Echinoderm whatever is known), there have been found twenty-eight good species of this group.* Of these the majority are forms of wide distribution, but a few of them have some special interest.

Such is the case with our one Crinoid, our single representative of a group which is of such great palæontological impor-

* This is the number which the writer had found reported at the time of writing this paper, and it probably includes all that have ever been reported *in print*. As this paper is passing through the press, however, Prof. Verrill, in a letter to the writer, says that there are many other species known to him to occur in the Bay of Fundy, all of which will be referred to in a future report. Prof. Verrill mentions specially six more Holothurians, three Starfishes and four Ophiurans.

tance. It is a *Comatula*, one of that division of the Crinoids in which the adult is free but the young is stalked. But there is some question about its exact identity. Dr. Stimpson in his Synopsis tells us that he dredged a single specimen of a *Comatula* in twenty-five fathoms near Duck Island, Grand Manan. He referred it, though doubtfully, to *Alecto* (now *Antedon*) *Eschrichtii*, finding differences which he thought might be due to age, as his specimen was only four inches in diameter, while those with which he compared it were at least ten. Dr. P. H. Carpenter, in his forthcoming report (Y), on the Crinoids of the CHALLENGER expedition (for advance sheets of which the writer cannot sufficiently thank him), suggests that Stimpson's specimen may have been *Antedon quadrata*, a smaller species of similar distribution which very greatly resembles and is very closely allied to *Antedon Eschrichtii*. Small specimens of the latter species, together with the former species were dredged by the "Challenger" off Nova Scotia, at the same locality on Le Have Bank, latitude $43^{\circ} 4' N.$, longitude $64^{\circ} 5' W.$, this being the most southerly known locality for both species. The known facts of distribution of the two species, therefore, do not help us, and as Dr. Stimpson's specimen was probably lost in the great Chicago fire of 1871, in which so much of his valuable material was destroyed, the question can now only be settled by its re-discovery. Whichever it may prove to be, it certainly is very rare in the Bay of Fundy, for the thorough dredgings of the United States Fish Commission failed to discover it. How the two species may be distinguished will be pointed out in the description of *A. Eschrichtii*.

Of Ophiuroids we have six species, all of them rather common forms. The most interesting is *Gorgonocephalus (Astrophyton) Agassizii*, the basket-fish, which is found upon the southern coast, on Bradele Bank, and at one or two other points in the Gulf of St. Lawrence.

Of true Starfishes we have eleven species, all of them of rather wide distribution, but some of them remarkable either for beauty of coloring or the arrangement of their hard parts. *Goniaster phrygiana* or *Crossaster papposa* are examples of

the former, *Otenodiscus crispatus* of the latter. It is an interesting question whether *Asterias Forbesii* will upon further search be found upon our North Shore. This is a Starfish which is very abundant on the coast in and south of Massachusetts Bay, associated there with *Asterias vulgaris*, the common form of our own shores. It belongs essentially to the southern fauna which occupies the great shallow basin of the southern part of the Gulf, and has been found by Prof. Verrill at Casco Bay, Maine, where a similar isolated southern colony occurs. It seems altogether probable, therefore, that it will be found in Northumberland Straits, the more especially as *Caudina arenata*, a southern Holothurian of very similar range, occurs there. It may be readily distinguished when alive from *A. vulgaris* by its usually greenish color and the bright red madreporic body in the angle between two of the rays, that of *A. vulgaris* being yellow. The only one of the Starfishes which is of any economic importance is the last-mentioned species, *Asterias vulgaris*, which is sometimes but to a very limited extent used as a fertilizer. It is also very injurious to oyster-beds, devouring great numbers of oysters.

Of Echinoids or Sea-urchins we have but two species in the Acadian fauna proper, and one straggler from the colder waters of the Nova Scotia banks. The two former *Strongylocentrotus dröbachiensis* and *Echinarachnius parma* are remarkable for their wide distribution, and *S. dröbachiensis* for its great abundance. One can appreciate when he sees our shores in some places fairly carpeted with this species, the well known fact that as we approach the poles the number of species diminishes but that of individuals increases. In some parts of the world Sea-urchins are eaten, but ours probably have little value for such a purpose, though Dr. Stimpson has tried them and found them edible, and the Exquimaux are said to eat their "spawn" or ova. *Echinarachnius parma*, according to Prof. Verrill, has a limited economic value for the indelible ink which may be made from its pulverized skin and spines.

Of Holothurians there are seven or eight species in our waters, only three or four of which are common. It is in this

group, if anywhere, that utilizable Echinoderms occur. In certain parts of the world, Holothurians are greatly esteemed as articles of food. A Mediterranean species is eaten in Naples; and the Chinese and Malays are exceedingly fond of it, so much so that it is among them a very important article of trade, the business employing hundreds of small vessels annually. They are generally known as Trepangs, and are prepared by being cleaned, dried and pressed. Our Holothurians belong to different genera, and may not be utilizable in this way to any extent. But the subject has not been left altogether uninvestigated, for Dr. Stimpson tells us that while in Nova Scotia he tried them with satisfactory gastronomic results. In the Proceedings of the Boston Society of Natural History, Vol. IV., 1851, p. 100, we find this passage: "As to the value of the Holothuridæ as articles of food, Mr. Stimpson said he had availed himself of the abundance by which he was surrounded at Nova Scotia, and had found them (*i. e.* the Holothurians) when boiled, quite as palatable as lobsters. The same was true of some of the Echini of that region." He undoubtedly refers to the common *Pentacta frondosa* or "sea-pumpkin" which is so abundant upon our southern coast. Alexander Agassiz says of it: "The *Pentacta* resembles the Trepang, so highly valued by the Chinese as an article of food, and forms a not unseamy dish, having somewhat the flavor of lobster." *Caudina arenata*, a southern Holothurian, is found on the North Shore, but not in the Bay of Fundy.

But we must glance for a moment at the general conclusions in regard to distribution and the like, to which we are led by the study of the Echinoderms in connection with other groups of Invertebrates. The writer has already had the honor to lay before this Society a brief discussion of the relations of the faunæ of the Acadian waters, so that a brief summary will be sufficient here. The extension of our knowledge of the subject can be briefly stated. In 1852, James D. Dana (in the Crustacea of the United States Exploring Expedition) pointed out the existence for the Crustacea of a sub-fauna which extended, according to him, from the eastern point of Newfoundland to Cape Cod, including the southern part of the

Gulf of St. Lawrence. To it he gave the name of Nova Scotia fauna. In 1857 (E), Lütken, from a study of the Echinodermata, established a sub-fauna of coincident range, but gave it the more appropriate name of Acadian fauna, a name which it still retains. In 1863 (I), Prof. Packard, reasoning chiefly from the mollusca collected on the coast of Labrador, came to the conclusion that there was a special colder water fauna occupying a great part of the Gulf of St. Lawrence, distinct from the Acadian fauna proper. This he knew extended outside the Gulf and southward on some of the banks off the Maine coast, particularly St. George's Bank. Being thus, south of Labrador, a shoal fauna, he called it Syrtensian. The later researches of the United States Fish Commission under the direction of himself and Prof. Verrill, defined more clearly its limits and showed that it occupies all the banks off the Nova Scotia and Maine coasts as far as St. George's Bank. They found, also, that it has outliers occupying the deeper parts at the mouth of the Bay of Fundy, and at one or two other points in the Gulf of Maine. Mr. Whiteaves has confirmed the presence of this Syrtensian fauna in the Gulf of St. Lawrence and shown that, with the exception of small outliers on Orphan and Bradelle Banks, it is sharply marked off from the Acadian fauna which occupies the southern part of the Gulf. A line drawn from the northernmost point of Cape Breton Island to the northernmost of the Magdalenes, and thence to the northern entrance of Bay Chaleur will separate these two faunæ. The different marine faunal sub-regions then, of the northeastern coast of America, may be summarized as follows. There is first the Circumpolar, occupying all the region of Davis Strait, the coast of Greenland, and the northern part of the coast of Labrador. South of this comes the Syrtensian, which occupies the southern part of the coast of Labrador, the waters to the east of Newfoundland including the Grand Bank, the Straits of Belleisle, all the deeper parts of the Gulf of St. Lawrence with outliers on Orphan and Bradelle Banks, the passage between Cape Breton and Newfoundland, Sable Island and the other banks off the Nova Scotia and Maine coasts, certain deep portions of the

Bay of Fundy and Gulf of Maine, and St. George's Bank. The Acadian fauna occupies all the southern part of the Gulf of St. Lawrence, probably parts of the southern shore of Newfoundland, the shores of Nova Scotia, all the Bay of Fundy, except the deep Syrtesian area at its mouth, all the coast to Massachusetts Bay, and here it begins to mingle with the southern fauna, named by Lütken the Virginian. South of Cape Cod the latter entirely replaces it, with the exception of Nantucket Shoals, which are still occupied by the Acadian, and a bank off the coast of New Jersey, where the last traces of the latter are found.

The Acadian fauna, however, is not, so to speak, homogeneous. It has been clearly shown that certain portions of it belong more nearly to the Virginian than the Acadian regions. This is the case with a large proportion of the forms in the great shallow southern basin of the Gulf of St. Lawrence, at certain sheltered and isolated points on the Atlantic coast of Nova Scotia and in a portion of Casco Bay, Maine. The fauna upon our North Shore is decidedly more southern than that in the Bay of Fundy, and a sub-division of the Acadian fauna would seem to be possible, though these more southern assemblages may also be considered simply as Virginian outliers. The causes determining this curious distribution of faunæ are purely physical, and have already been discussed by the writer before this Society.

Harvard University, Cambridge, Mass.,
February 4th, 1888.

II. BIBLIOGRAPHY.

It is thought that the following list includes all works and papers of importance which relate to New Brunswick Echino-dermata. Only the most important, most generally useful, and most easily accessible structural or systematic works are given; reference to them will show the student bibliographies of others of like character. A few popular works, such as those of Forbes (A), and Agassiz (K), have been introduced on account of the exceptionally interesting way in which they

treat the subject. One or two others, such as the papers of Fuller (G), etc., are added for the sake of completeness rather than for any special value they have.

(A) 1841. **Forbes, Edward.**

A History of British Starfishes and other Animals of the Class Echinodermata. *London*. 8vo. xx.+269 pp., woodcuts.

(A truly classical work and one of the greatest interest, as well as of very considerable value to all students of our Echinodermata).

(B) 1851. **Stimpson, William.**

[Observations on the Fauna of the Islands at the mouth of the Bay of Fundy, and on the extreme northeast corner of Maine]. *Proceedings of the Boston Society of Natural History*, Vol. IV. pp. 95-100.

(A paper more interesting historically than otherwise, as its substance is embodied in his Synopsis).

(C) 1851-1854. **Ayres, W. O.**

[Descriptions of new Holothuridæ]. *Proceedings of the Boston Society of Natural History*, Vol. IV.; a series of papers, but particularly pp. 25, 35-37, 52-53, 143-145, 243-246.

(Very valuable for the descriptions of our Holothurians).

(D) 1854. **Stimpson, William.**

Synopsis of the Marine Invertebrata of Grand Manan: or the Region about the Mouth of the Bay of Fundy, New Brunswick. *Smithsonian Contributions to Knowledge*, Vol. VI. 4to. 67 pp., 3 Plates.

(Much the most important work that has yet appeared specially upon the Invertebrate Fauna of this region.)

(E) 1857. **Lütken, Chr. Fr.**

Om de Nordiske Echinodermers Geographiske Udbredning, [On the Geographical Distribution of Norwegian Echinoderms]. *Videnskabelige Meddelelser . . . I Kjöbenhavn*. 1857-59. pp. 56-100.

(In this paper Lütken establishes the Acadian Fauna).

(F) 1858. **Lütken, Chr. Fr.**

Addimenta ad historiam Ophiuridarum. Parts I. and II. *Kjöbenhavn*. 4to. 169 pp., 7 plates.

(Important for its descriptions and figures of Ophiuroids).

(G) 1861. **Fuller, C. B.**

[Note on the Marine Animals of Eastport Harbor]. *Proceedings of the Portland Natural History Society*, Vol. I., p. 91.

(Mentions a few Echinoderms. Given for the sake of completeness).

(H) 1868. **Fuller, C. B.**

Report on Marine Zoology [of Maine]. *Second Annual Report upon the Natural History and Geology of the State of Maine*, 1862, pp. 129-183.

(Contains references to Echinoderms found at Eastport and in the St. Croix River).

(I) 1863. **Packard, A. S., Jr.**

A list of Animals dredged near Caribou Island, Southern Labrador, during July and August, 1860. *Canadian Naturalist*, Vol. VIII., pp. 401-420, 2 plates.

Also—Observations on the Glacial Phenomena of Labrador and Maine, with a View of the recent invertebrate Fauna of Labrador. *Memoirs of the Boston Society of Natural History*, Vol. I., 1867., pp. 210-303, 2 plates.

(Important for their bearing on the Syrtensian Fauna of the Gulf of St. Lawrence.)

(J) 1865. **Lyman, Theodore.**

Ophiuridæ and Astrophytidæ. *Memoirs of the Museum of Comparative Zoölogy*, Cambridge, Mass., Vol. I., (Illustrated Catalogue No. 1) 4to. vii. + 200 pp., woodcuts and 2 plates.

(The most important systematic work on New England Ophiuroids).

(K) 1865. **Agassiz, Elizabeth C. and Alexander.**

Seaside Studies in Natural History. *Boston*. 8vo. xii. + 157 pp., woodcuts.

(A valuable book, treating the common New England Echinoderms in a very interesting way, and giving good figures of many of them).

(L) 1866. **Verrill, A. E.**

On the Polyps and Echinoderms of New England, with Descriptions of new Species. *Proceedings of the Boston Society of Natural History*, Vol. X. 8vo. pp. 333-357.

(A very important paper, correcting the synonymy up to date and describing the range on our coast of each species).

(M) 1867. **Selenka, Emil.**

Beiträge zur anatomie und systematik der Holothurien. [Contributions to the Anatomy and Classification of the Holothurians]. *Zeitschrift für Wissenschaftliche Zoologie* [Leipzig]. Vol. XVII, pp. 291-374, 4 plates.

(An important work on our Holothurians, particularly on their anatomy).

(N) 1871. **Verrill, A. E.**

Marine Fauna of Eastport, Me. *Pulletin of the Essex Institute*, Vol. III. pp. 2-6.

(Describes the character of the tides among the islands, etc., and gives quite a complete list of the Echinoderms of the neighboring shallow waters).

(O) 1872-1874. **Agassiz, Alexander.**

Revision of the Echini. *Memoirs of the Museum of Comparative Zoölogy, Cambridge, Mass.* Vol. III. (Illustrated Catalogue No. 7). 4to. xii.+762 pp., 49 plates.

(By far the best work we have on the Echinoids).

(P) 1872-73-74. **Whiteaves, J. F.**

Reports on Deep Sea Dredging Operations in the Gulf of St. Lawrence. 3 Reports. *Annual Report of the Department of Marine and Fisheries, Canada.* Appendix K, Report for 1870-71, pp. 90-101; Appendix K, Report for 1871-72, pp. 113-132; Appendix U, Report for 1872-73, pp. 178-204.

These Reports embody the results of the following:

Deep Sea Dredging in the Gulf of St. Lawrence. *Nature*, Vol. V., 1871, p. 8.

Reprinted in *Canadian Naturalist*, Vol. VI., new series, 1872, pp. 351-354.

Notes on a Deep Sea Dredging Expedition round the Island of Anticosti, in the Gulf of St. Lawrence. *Annals and Magazine of Natural History*, iii., Vol. X., 1872, pp. 341-354.

Reprinted with additions in the *Canadian Naturalist*, Vol. VII., 1873, pp. 86-100.

On recent Deep-Sea Dredging Operations in the Gulf of St. Lawrence. *American Journal of Science*, iii, Vol. VII, 1874, pp. 210-219.

Reprinted in *Canadian Naturalist*, new series, Vol. VII., 1874, pp. 257-267.

(In these Reports and papers are contained nearly everything that we know of the Echinoderm Fauna of the Gulf of St. Lawrence, particularly its deeper parts).

(Q) 1873. **Verrill, A. E.**

Report upon the Invertebrate Animals of Vineyard Sound and the adjacent waters, with an account of the physical characters of the region. *Report of the U. S. Fish Commission for 1871-72*. 8vo. pp. 293-778, 38 plates and map.

(A very important work, referring frequently to forms which are found in the Bay of Fundy.)

(R) 1873-1874. **Verrill, A. E.**

Results of recent dredging Expeditions on the Coast of New England. *American Journal of Science*, Vol. V., pp. 1-16 and 98-106; Vol. VI., pp. 435-441; Vol. VII., pp. 38-46, 181-138, 405-414, 498-505.

(Mentions a few New Brunswick Echinoderms, but chiefly valuable for discussion of physical features of the region, faunal relations, etc.)

(S) 1876. **Verrill, A. E.**

Note on some of the Starfishes of the New England coast. *American Journal of Science*, iii., Vol. XI., pp. 416-420.

(Very important as distinguishing our common shore species of Starfishes.)

(T) 1877. **Agassiz, Alexander.**

North American Starfishes. *Memoirs of the Museum of Comparative Zoölogy, Cambridge, Mass.* Vol. V., iv. +136 pp., 20 plates. (Treats of the hard parts of several of our Starfishes.)

(U) 1881. **Duncan, P. Martin, and Sladen, W. Percy.**

A Memoir on the Echinodermata of the Arctic Sea to the West of Greenland. *London*. 4to. viii. +82 pp., 6 plates.

(The most important single work on many of the Echinoderms which occur in this region, and of the greatest value to a student of the group.)

(V) 1882. **Lyman, Theodore.**

Report on the Ophiuroidea dredged by H. M. S. CHALLENGER, during the years 1873-1876. *Report on the Scientific Results of the Voyage of H. M. S. CHALLENGER. Zoölogy*, Vol. V. 4to. viii. +386 pp., 48 plates.

(A monograph, practically, of all known Ophiuroids.)

(W) 1882. **Verrill, A. E.**

[Review of Duncan and Sladen's Memoir on Arctic Echinodermata]. *American Journal of Science*, iii., Vol. XXIII., pp. 247-248.

(Contains some notes on the range of our species southward).

(X) 1885. **Ganong, W. F.**

On the Zoology of the Invertebrate Animals of Passamaquoddy Bay. *Bulletin of the Natural History Society of N. B.*, No. IV., pp. 87-97.

Also—A Note in *Bulletin No. V.*, pp. 84-86.

(Mentions the occurrence of a few species on the southern coast).

(Y) 1888. **Carpenter, P. Herbert.**

Report on the Crinoidea dredged by H.M.S. CHALLENGER during the years 1878-1879. *Report on the Scientific Results of the Voyage of H. M. S. CHALLENGER, Zoölogy*, Vol. —. 4to.

(Has not yet appeared, but will be a most valuable treatise on the Crinoidea).

III. SYNOPSIS OF THE ECHINODERMATA OF NEW BRUNSWICK.

The present Synopsis is intended to supply, firstly, a list of all Echinodermata known from New Brunswick waters, and, secondly, a guide for their further study. The references to descriptions and figures are not to the first which were given or made of each species, but to the best and most easily accessible. The brief descriptions in the following pages are intended merely as guides to serve as means for the identification of the species, and are not intended to be in any sense anatomical or complete. It is hoped, however, that they will be found accurate as far as they go. Only the superficial characters have been used, and generally such as can be seen at a glance. Technical terms have been as far as possible avoided, and those which are used are such as are self-explanatory or found in any of the elementary zoological text-books. It is only possible to distinguish between species in this superficial way when their number is small and they

belong generally to different genera, and such is the case with the species of our waters.

In the nomenclature, the name which is supported by the best authority is in all cases given first. After each is given in brackets the name of the Naturalist who first gave the species the specific name it bears, and after that the name of the one who placed it in the genus in which it appears, or in other words who first used the combination of generic and specific names. When the describer of a species placed it in the genus in which it now remains, his name is given after that of the species without brackets. It will be noticed that pre-Linnaean names have in no case been recognized. One feels great regret at thus passing over such an author as Linck and his grand old work "*De Stellis Marinis*," but if his nomenclature is adopted that of other works published before the inception of the binominal system of nomenclature must also be recognized, and hopeless confusion would result. The synonymy is only so far treated as is necessary to a proper understanding of the works quoted.

Among our coast waters are included the whole of the Bay of Fundy, but for reasons mentioned in the preceding pages, only the shallower parts of the Gulf of St. Lawrence. For the sake of comparison, however, with the Bay of Fundy fauna, mention is made of the occurrence of species in the deeper parts of the Gulf which occur also in the Bay, and those occurring in the former and not in the latter are given in a separate list. For all localities for which no authority is given the writer is responsible. The letters in brackets refer, of course, to the Bibliography.

ECHINODERMATA.

Animals having a radial, usually pentamerous arrangements of parts, a skin bearing spicules and hardened, usually to a great degree, by calcareous deposits, a digestive canal, a water-vascular apparatus, and a true vascular system.

Class I. CRINOIDEA (CRINOIDS).

Globular or cup-shaped Echinodermata with segmented arms, bearing pinnulae, usually attached by a calcareous segmented stalk with plates on the skin of the dorsal side, and ambulacral appendages in the form of tentacles situated in the ambulacral furrows of the disc and arms.

FAMILY COMATULIDÆ.

Stalked only in the young state, adult free, arms ten.

1. **Antedon Eschrichti**, (MÜLLER), VERRILL. *Alecto Eschrichtii*, MÜLL. et TROSC. (D). [See Plate, Fig. 1.]

One of the "Comatulæ."

DESCRIPTION. (U) p. 73, (Y) p. 138.

FIGURE. (U) pl. VI., (Y) pl. XXVI.

DISTRIBUTION. (a) *General*;—From five to six hundred and fifty fathoms. North Atlantic and Arctic Oceans from Smith Sound to the Vega. Off Nova Scotia in lat. $43^{\circ} 4'$ N., long. $64^{\circ} 5'$ W. Bay of Fundy (?).

(b) *In N. B. waters*;—A single small specimen was taken in twenty-five fathoms on a shelly bottom off Duck Island, near Grand Manan, by Dr. Stimpson in 1852.

This species, as is shown by its distribution given above, is decidedly Arctic, and does not belong to the Acadian fauna. Only a single specimen has been yet found, and he who re-discovers it will be fortunate indeed.

It is one of the largest of the Comatulæ, some specimens measuring twenty inches in extreme diameter with the arms outspread. The dorso-central plate bears a great number, even as many as one hundred cirrhi, each consisting of from forty to sixty joints, by which it attaches itself to the bottom. The mouth is in the centre of the upper (though structurally the lower) side, and from it the ambulacral furrows radiate to the ten long arms. The latter ordinarily point upwards, and, having

each a double curve, form collectively an urn-shaped figure. Each arm is composed of many joints (up to three hundred in the largest specimens) and bears two rows, which coalesce towards the extremities of the arms, of pinnules, each of which consists of from thirty to one hundred joints, and the lowermost of which, on account of a row of dorsal tubercles, have a serrate appearance.

It lives upon mud, sand and rock bottoms, but almost nothing is known of its habits. In its development from the egg it passes through a metamorphosis, beginning with a barrel-shaped larva with four encircling bands of cilia, and passing on to a stalked stage in which it resembles the adult condition of the fixed crinoids. Afterwards it becomes free.

It has been pointed out (Y), that Stimpson's specimen may have been *Antedon quadrata* and not *A. Eschrichti*. So closely allied are these two species that some naturalists consider them to be one, and at the best it is only with difficulty that they can be distinguished. The shape of certain joints of the arms and relative length of certain pinnules are the most obvious characters which separate them.

Class II. ASTEROIDEA (STARFISHES).

Pentagonal or star-shaped dorso-ventrally compressed Echinoderms with ambulacral feet confined to the ventral surface, and internal skeletal pieces in the ambulacra articulated together like vertebrae.

Order I. OPHIURIDEA (THE SNAKE-STARS).

Asteroidea with long cylindrical arms sharply distinct from the disk, not containing appendages of the alimentary canal; ambulacral groove covered by plates so that the ambulacral feet project at the sides of the arms.

FAMILY EURYALIDÆ.

Mostly with branched arms which can be curved towards the mouth and are without plates, with a soft skin closing the ventral groove.

2. **Gorgonocephalus Agassizii**, (STIMPSON), LYMAN. *As-trophyton Agassizii*, St. (D), etc. [See Plate, Fig. 2.]

Basket-fish. Sea-spider.

DESCRIPTION. (D) p. 12, (J) p. 186, (U) p. 69.

FIGURE. (K) p. 151, (U) pl. V.

DISTRIBUTION. (a) *General*;—Low-water mark to 800 fathoms. South of Cape Cod, Bay of Fundy, Gulf of St. Lawrence, Davis Strait, Smith Sound, Vadsø, Finmark.

(b) *In N. B. waters*;—Grand Manan, coralline zone, not uncommon, *Stimpson*, (D). Eastport Harbor, "at low-water of spring tides among rocks (mostly small specimens), and abundantly, of all sizes from half an inch to eighteen inches or more in diameter, in fifteen to twenty fathoms, shelly and stony bottom." *Verrill*, (L), (N), (Q). Friar's Cove, *Ganong*, (X). Bay of Fundy, very common, low water to 100 fathoms, *Verrill*, (Q). Bradelle Bank, Gulf of St. Lawrence; *Whiteaves*, (P). Black's Harbor, near Letete Passage, Charlotte County.

This very interesting Echinoderm is quite abundant on our southern coast. It is a true Ophiuran, differing from the common forms chiefly in its greater size and the branching of its arms. The disk, which is from two to two and a half inches in diameter, is pentagonal and covered with a brownish skin having small granules, which, upon the ten very evident radiating ribs, become large tubercles or blunt spines. On the under side the skin is covered with small granules and fills the spaces between the arms, at the bases of which is the mouth with conspicuous papillæ and teeth, and on each side of which, just as they emerge from the disk, are the genital openings. The arms, five in number, as they spring from the disk, immediately divide each into two, the branches again soon dividing in a like manner, the branchlets also dividing, and so on, until at their extremities the arms have become an immense number of very slender, roughened twigs. The branching is not, however, truly dichotomous*—that is, the two branches are never exactly equal, but one is larger than the other—a large and a small one following each other at unequal intervals along any given arm. If the branching were dichotomous, a specimen with twelve forks to each of the arms would have about 20,480 terminal twigs, whereas the mode of branching above mentioned produces about 5,470. The arms are covered above with a rough granular skin of yellow color with no visible external plates; below it is smooth and soft and on the outer under sides of each arm and branchlet runs a triple row of short, blunt spines.

The extremities of the arms can be brought around towards the mouth, and it is usually in this position, having them much tangled and interlaced, that the animal dies, and is seen in preserved specimens, showing well why it is called Basket-fish. While alive, however, it keeps them expanded, using them to catch the small animals which form a part of its food. According to Alexander Agassiz (K), "In moving the animal lifts itself on the extreme end of these branches,

* As shown by Mr. Lyman. See *Proceed. Bost. Soc. Nat. Hist.* Vol. XIX., 1876-78, p. 102.

standing as it were on tiptoe, so that the ramifications of the arms form a kind of trellis work all around it, reaching to the ground, while the disk forms a roof. In this living house with latticed walls small fishes and other animals are occasionally seen to take shelter; but woe to the little shrimp or fish who seeks refuge there, if he be of such a size as to offer his host a tempting mouthful." It is often brought up by the fishermen on their lines and nets, but owing to its living only in very cold water, it is very difficult to keep it alive. Hence little is known of its habits and nothing of its development. Whether it be viviparous or passes through a metamorphosis is uncertain, but certain points in its structure would seem to indicate the former. The youngest stage ever found had a single fork in the arm, and resembled otherwise a young *Ophiopholis aculeata*.

FAMILY OPHIURIDÆ.

With simple unbranched arms and ventral plates to the ambulacral grooves.

3. *Ophiacantha bidentata*, (RETZIUS), LJUNGMAN.

Ophiacantha spinulosa, M. et T. (D) etc.

DESCRIPTION. (J) p. 93, (U) p. 68.

FIGURE. (F) pl. II., (U) pl. IV.

DISTRIBUTION. (a) *General*.—Ten to below one thousand fathoms. South of Cape Cod to the Arctic Ocean, North Atlantic to Norway and Spitzbergen.

(b) *In N. B. waters*.—Grand Manan, coralline zone, shelly bottoms, sparingly, *Stimpson*, (D). Bay of Fundy, four or five miles off the eastern end of Campobello, 100 to 125 fathoms, mud and broken shells, *Verrill*, (N). Gulf of St. Lawrence, abundant in 100 to 250 fathoms, as well as in shallow water, *Whiteaves*, (P).

This is a "Syrtensian" rather than an "Acadian" species, and hence rarely met with in our shallow waters. It has been very appropriately named "*spinulosa*," for both disk and arms fairly bristle with spines. The disk, which is from one-third to one-half an inch in diameter, is evenly covered both above and below with short, stout cylinders, each of which ends in a rounded crown of fine thorns. The mouth has six or seven papillæ to each of its angles. The arms are between four and five times as long as the diameter of the disk. The side arm plates are large, meeting both above and below along the whole length of the arm; the upper arm-plates show a small triangular, and the lower a squarish or shield-shaped portion. Each side arm-plate bears about seven long, slender, tapering spines.

Nothing is known of the development of this species and almost nothing of its habits. It seems to prefer muddy and shelly bottoms, is never found above low-water mark, and lives only in cold, clear water.

4. ***Amphiura squamata***, (DELLE CHIAJE). SARS. *Ophioplepis tenuis*, AYRES (D). *Amphipholis elegans*, LJUNGMAN (Q).

DESCRIPTION. (J) p. 121.

FIGURE. (F) pl. III. (under name *A. tenera*).

DISTRIBUTION. (a) *General*;—Low-water mark to 120 fathoms. Almost cosmopolitan. New Jersey to the Arctic Ocean, Northern Europe to and in the Mediterranean, Cape of Good Hope, and Southern Pacific near Australia.

(b) *In N. B. waters*;—Grand Manan, among nullipores, below low-water mark, frequent, *Stimpson*, (D). Eastport, twenty fathoms, shelly bottom, sparingly, *Verrill*, (L), (N). Bay of Fundy, low-water to sixty fathoms, common, *Verrill*, (Q).

This is a very small but pretty and graceful Ophiuran. The disk, one-fifth of an inch in diameter, is covered with overlapping scales of about equal size, with a sharp line where those of the upper meet the projecting edges of those of the lower surface. The arms are about four-fifths of an inch long, slender and very flexible. The lower arm-plates are shield-shaped, the upper rounded and slightly separated by the encroachment of those of the side, which encroach more above than below. There are three short, blunt, nearly equal arm-spines to each side-plate, the upper of which is a little the stoutest. It is generally greyish in color, with occasional reddish markings, and found among broken shells, under which it hides itself. It possesses special interest from the fact that it is viviparous. If old individuals be opened in August they will be found to contain several orange colored young. The eggs being protected within the body of the mother, their development is without a metamorphosis.

This species has not yet been reported from the Gulf of St. Lawrence, but it ought to occur there, both in the deep and shallow parts, and will probably be found after further search.

5. ***Ophiopholis aculeata***, (RETZIUS), GRAY. *Ophiopholis scolopendrica*, M. et T. (D). *Ophiopholis bellis*, LYMAN (J). [See Plate, Fig. 3.]

Daisy Serpent-star. Daisy Brittle-star.

DESCRIPTION. (A) p. 53, (J) p. 96.

FIGURE. (A) p. 53, (J) pl. I., (K), p. 115, (F) pl. II., (Q) Fig. 270, etc.

DISTRIBUTION. (a) *General*;—Littoral to 1,000 fathoms. South of 40° N. to Arctic Ocean, all around North Atlantic to the English Channel and Ireland, Spitzbergen, Alaska.

(b) *In N. B. waters*;—Grand Manan, laminarian zone, excessively common, *Stimpson*, (D). Eastport, low water to twenty fathoms, very common, *Verrill*, (L), (N). Bay of Fundy, very common, low water to 100 fathoms, *Verrill*, (Q). Abundant in pools on southern coast, *Ganong*, (X). Common in the Gulf of St. Lawrence, *Whiteaves*, (P).

This is by far the most abundant, most easily obtained and most beautiful and graceful of all our Ophiurans. It exists everywhere upon the southern coast, and may be found in large numbers about low-water mark by turning over stones and looking under ledges. Its disk, which is one-half to three-quarters of an inch in diameter, is pentagonal in shape, bulging out between the rays. It is closely beset above with short flattened spines except on the distinct primary and radial plates. On the under side the arms spring from near the mouth, of which the papillæ, six to each angle, and the teeth, are distinctly seen. The arms are three to four inches long in the largest specimens. The upper arm-plates are oval in form, each being surrounded by a row of small supplementary pieces, "seeming like a brooch set in a frame of gems," as Forbes says; one row, however, is common to two plates where the latter are adjacent to one another. Under arm-plates are squarish, side arm-plates inconspicuous, but each bearing about six arm-spines, so that there are about six on each side of each segment of the arm. There is the greatest variation in color, scarcely any two individuals being alike in this respect. Mottled with various shades of yellow, orange, red, green, almost every conceivable combination of patterns involving these colors may be found.

If one wishes to find them he must look in the most sheltered and rocky places, for they hide themselves away in all sorts of nooks and dark places. They are exceedingly graceful in their motions, having the power of moving their arms in every direction with sinuous snake-like ease and rapidity, showing well how the group received its name of Ophiurans or Snake-tails. They are greedily eaten by the cod, though one would think there could be but little nourishment in their hard bodies. In their development they pass through a complicated metamorphosis. The eggs are cast into the water, and after a series of changes result in a free swimming easel-shaped larva of complicated structure. From a portion of this, near the mouth, the young Ophiuran begins to form, absorbing the substance of the larva as it grows.

6. **Ophioglypha robusta**, (AYRES), LYMAN. *Ophiolepis robusta*, AYRES (D). [See Plate, Fig. 3x.]

DESCRIPTION. (J) p. 45, (U) p. 62.

FIGURE. (F) pl. I. [under name *Ophiura squamosa*], (U) pl. IV.

DISTRIBUTION. (a) *General*;—Low-water mark to 150 fathoms. Massachusetts Bay to Greenland, Arctic Ocean, Northern Europe, Alaska.

(b) *In N. B. waters*;—Grand Manan, low-water mark and laminarian zone, abundant, *Stimpson*, (D). Eastport, low-water to twenty fathoms, frequent, *Verrill*, (L), (N). East of Campobello, 100 to 125 fathoms, *Verrill*, (N). Gulf of St. Lawrence, "very sparingly met with," *Whiteaves* (F).

This species resembles somewhat *O. Sarsii*, but is much smaller and differently colored. The disk is one-third of an inch in diameter and covered above with regularly arranged and nearly equal scales. The mouth has seven papillæ to each angle. The arms are one and one-fourth inches long, tapering to mere threads. The upper arm-plates are diamond-shaped with rounded angles; side arm-plates meet below but not above until half way out on the arm; each bears three rounded, tapering, sharp spines, of which the upper is the largest. It varies greatly in color; it may be grey, variegated with red or black, or brown or even blue. It lives either upon rocky or mud bottoms, seeming to prefer the former. Nothing is known of its habits or development.

7. **Ophioglypha Sarsii**, (LÜTKEN), LYMAN. *Ophiolepis ciliata*, MÜLL. et TROSCHE. (D). [See Plate, Fig. 3y.]

One of the "Brittle-Stars."

DESCRIPTION. (J) p. 41, (U) p. 60.

FIGURE. (F) pl. I., (U) pl. IV.

DISTRIBUTION. (a) *General*;—Low-water mark to 1,600 fathoms. South of 40° N., to Greenland and Davis Strait, Northern Europe to Great Britain, Alaska.

(b) *In N. B. waters*;—Grand Manan, sixty fathoms, mud, *Stimpson*, (D). Eastport, large, not common, fifteen to twenty fathoms, stones, *Verrill*, (L), (N). Bay of Fundy to east of Campobello, 100 to 125 fathoms, *Verrill*, (N). Abundant on southern coast in ten fathoms, *Ganong*, (X). Very abundant and

of large size in Gulf of St. Lawrence in 25 and up to 250 fathoms; Bradelle Bank, large and frequent, *Whiteaves* (P).

This species is quite common in our waters in from five to thirty fathoms. It is of a grey color above, lighter beneath. The disk, which is one-half to three-fourths of an inch in diameter, is circular in form and covered above with rounded plates of different sizes, among which may be distinguished one central surrounded by five others, and one on each side of the base of each arm. The mouth has thirteen papillæ to each angle and conspicuous mouth shields. The arms are three to four times as long as the diameter of the disk. Upper arm-plates are large; side arm-plates nearly cover the under, and each bears three spines, giving them a triple row on each side. It can only move its arms in the plane of the body, and in a stiff and ungraceful way, making with them a sort of oar-like motion, by which it propels itself over the mud on which it lives. Nothing is known of its habits. Its development is direct and it is viviparous.

[Prof. Verrill writes as this paper is in press, that in the Bay of Fundy "of Ophiurans, *Ophioglypha signata*, V., is common, and there are additional species of *Ophiacantha*, *Ampbiura* and *Ophioscolex*."]

Order II. ASTERIDEA (TRUE STARFISHES).

Asteridea whose arms are prolongations of the disk, containing appendages of the alimentary canal and also the generative organs, possessing a deep uncovered ambulacral groove, running along the ventral surface, in which the ambulacral feet are arranged in rows.

FAMILY ASTERIDÆ

With the cylindrical ambulacral feet ending in broad suctional disks, and usually arranged in four rows along each ambulacral groove.

8. *Asterias vulgaris*, STIMPSON, MS. *Uraster rubens*, LIN. AG. (A). *Uraster violacea*, MÜLLER. (A). *Asteracanthion rubens*, M. et T. (D). *Asteracanthion violaceus*, M. et T. (D). [See Plate, Fig. 4*].

"Starfish," "Five-finger," "Crossfish."

DESCRIPTION. (A) pp. 83 and 91, (L) p. 347, (S) p. 418.

FIGURE. (A) pp. 83 and 91, *American Naturalist*, Vol. II., pl. VI., Fig. 11.

*Fig. 4 represents *A. Forbesii*, but as the characters which separate the species do not appear in a figure, it shows well the appearance of *A. vulgaris*.

DISTRIBUTION. (a) *General*.—Littoral to 208 fathoms. Long Island Sound to Labrador, European Seas [if identical with *A. rubens*].

(b) *In N. B. waters*.—Grand Manan, large and common, just below low-water mark, *Stimpson*, (D). Eastport and Grand Manan, abundant and large among rocks at low water, *Verrill*, (L). Eastport, *Verrill*, (N). Bay of Fundy, above low water mark to forty fathoms, very abundant, *Verrill* (Q). Passamaquoddy Bay, common everywhere, *Ganong*, (X). Shediac, on oyster beds, and other parts of the Gulf of St. Lawrence, *Whiteaves*, (P). Very abundant everywhere on the southern coast, and by far the most common species. At Bar Island, near the mouth of L'Etang harbor, particularly abundant and large.

A description of this species for purposes of identification is scarcely needed. It is typically the Startish of our coasts and is abundant almost everywhere on the rocks in clear water. The five long rays with their short blunt spines, surrounded by rings of pedicellariae, four regular rows of tube-feet, radiately-striated madreporic body and other characters of the species soon become familiar to the student. When adult it can be confounded with no other species upon our coast, though the identification of young specimens is not always easy. In color it is "usually reddish, purplish, or violet, varying to yellow and brown, but with a pale buff or cream-colored madreporic plate."* But the color and even the form of the animal varies with the sex, "season, state of the ovaries, age, dilation with water, etc."* The very large specimens found near the mouth of L'Etang harbor are either a pale purple, red, a cream color, yellow or a dull green. *Verrill* says (L) that in the Bay of Fundy it grows to be fifteen inches in diameter and upwards. The specimens at L'Etang, which are the largest the writer has seen, are a little over a foot in diameter.

The habits of this species can be easily studied. It is very hardy and will live for some time in glass vessels of water, and thrive under conditions which would quickly prove fatal to deep-water forms. In the tide-pools near low-water mark their method of locomotion, taking food, etc., may be readily seen, and in the glass vessels may be tried upon them many simple experiments which will readily suggest themselves to the earnest student.

Specimens are often found with only four, three, two, or even one perfect ray, and with the others either small or quite wanting. A care-

* *Verrill* (S).

ful search will usually show in the latter case the budding rudiments of the missing ones, which will soon grow to replace those which have been lost.

This very common species has unfortunately no economic value of any importance. The lime in its skeleton gives it sometimes a very limited value as a fertilizer. It is very injurious to oyster beds.

Its development is similar to that of *A. Forbesii*; there is a complicated metamorphosis, the larva (*Brachiolaria*) being free-swimming and bilaterally symmetrical.

[***Asterias Forbesii***, VERRILL *Astracanthion berylinus*,
AG. (K). [See Plate, Fig. 4].

DESCRIPTION. (K) p. 108, (L) p. 345, (S) p. 418, (T) p. 94.

FIGURE. (K) p. 110, (T) pl. IX.

DISTRIBUTION. (a) *General*;—Littoral to twenty fathoms. Casco Bay, Maine, to the Gulf of Mexico.

(b) *In N. B. waters*;—Not yet reported. [Verrill in 1866, (L), said:—"At Eastport, Me., and Grand Manan, it is very rare," but later he corrects this, (Q), "not known from the eastern part of the coast of Maine, nor in the Bay of Fundy." It is inserted here on account of the possibility of its occurring in the Gulf of St. Lawrence and to call attention to the necessity for a search being made for it there.]

In general, this species is very like *A. vulgaris*. The chief distinguishing characters are to be found, according to Prof. Verrill, (S), in the color, and form of the pedicellariæ and of the adambulacral spines. As to the color, "*A. Forbesii* is generally greenish, varying to orange and brown, with a bright orange madreporic plate; while *A. vulgaris* is usually reddish, purplish, or violet, varying to yellow and brown, but with a pale buff or cream-colored madreporic plate."

As to the other characters, Prof. Verrill says:—"In *A. Forbesii* the major pedicellariæ [*i. e.* the larger sessile pedicellariæ borne over the surface or on the ventral spines] are short, ovate, blunt-pointed, hardly longer than broad; the adambulacral spines are stout, obtuse and in most cases, many are more or less flattened and grooved externally at tip."

"In *A. vulgaris*, the major pedicellariæ are lanceolate, sharp-pointed, much longer than broad; the adambulacral spines are larger, more pointed and seldom flattened."

The characters, however, of most use to our collectors will doubtless be found to be, the greenish color of the animal and (particularly) the bright orange color of the madreporic plate.

In habits it is similar to *A. vulgaris*. Its development has been very carefully worked out by Alexander Agassiz. The eggs are cast out into the water, and after a series of changes result in a larva which is so different from the adult that its relationship was not for a time suspected, and it was described as a separate animal under the name of *Brachiolaria*. (See Plate, Fig. 5). Its appearance is well shown by the figure. It leads an entirely independent existence, taking and digesting food for itself and swimming freely about by means of a long band of vibratile cilia. The adult Starfish buds off from a point near the mouth and grows at the expense of the larva, gradually absorbing the substance of the latter] as it increases in size.

9. ***Asterias littoralis***. (STIMPSON), VERRILL. *Asteracanthion littoralis*, St. (D). [*Asterias Grænlandicus*, STEENSTRUP (P).] *Leptasterias littoralis* (S).

DESCRIPTION. (D) p. 14.

FIGURE.

DISTRIBUTION. (a) *General*;—Between tide-marks to forty or fifty fathoms. Bay of Fundy and Gulf of St. Lawrence.

(b) *In N. B. waters*;—Grand Manan, "very common among the fuci in the middle region of the littoral zone, or even near high-water mark—elsewhere I have never found it," Stimpson, (D). "Eastport and Grand Manan, abundant from half-tide to low-water mark, among rocks and fuci," Verrill, (L), on the shores, (N). Gulf of St. Lawrence, Whiteaves, (P). [Mr. Whiteaves now considers the specimens mentioned in his reports under the name *A. Grænlandicum* to belong to this species.]

This species is very appropriately named "*littoralis*," for it is one of the commonest of littoral forms. Stimpson (D), describes it as follows: "Body tumid, rays very broad. Ambulacral spines in two rows, slender, blunt, or even clavate at their tips. Spines on the sides larger than those on the back, but both short, blunt, and showing great uniformity in size and distribution. Its color is always a dark green above, and it never exceeds an inch and a half in diameter. It is very common among the fuci in the middle region of the littoral zone, or even near high-water mark—elsewhere I have never found it." Prof. Verrill in a letter to the writer says he has found it six to eight inches across, and in all depths down to forty or fifty fathoms. Nothing is known of its habits more than is indicated above, and we know nothing of its development.

10. **Asteracanthion Grœnlandicum**, (LÜTKEN.) {STEENSTRUP}. *Asteracanthion Mulleri*, SARS. (D), *Asterias Grœnlandica*, STP. (L), [p. 357.]

DESCRIPTION. (U) p. 27.

FIGURE. (U) pl. II.

DISTRIBUTION. (a) *General*; — Low-water mark to eighty fathoms. Grand Manan, Gulf of St. Lawrence, Labrador. Discovery Bay (north of Smith Sound), Assistance Bay, S.W. Coast of Nova Zembla.

(b) *In N. B. waters*; — Grand Manan, off northern point of Duck Island, thirty fathoms, *Stimpson*, (D). Gulf of St. Lawrence, near Anticosti, *Verrill*, (L). [The specimens from the Gulf referred to in Whiteaves' various reports as belonging to this species are now considered by him to be *A. littoralis*.]

This rather small Starfish, though presenting no striking peculiarities to the eye, may nevertheless be readily distinguished from all other species. It is rarely or never more than two inches in diameter, and looks at first sight much like a young *Asterias vulgaris*. The spines upon the sides of the rays are arranged in more or less regular lines, and each is surrounded at its base by a nearly or quite complete ring of pedicellariæ. This ring of pedicellariæ around the base of the spines on the sides of the arms affords one of the best characters for distinguishing the species. The pedicellariæ also form a fringe along the sides of the ambulacral furrow. The ambulacral spines stand in three to four rows and are long and cylindrical. In color it is variable, being sometimes, as in Stimpson's specimens, bright red, and also greyish or olive-green. It seems to prefer rocky bottoms, but nothing is known of its habits or development.

11. **Leptasterias tenera**, (STIMPSON), VERRILL. *Asterias tenera*, STIMPSON (Proc. Bost. Soc. VIII.)

DESCRIPTION. Proc. Bost. Soc. Nat. Hist., Vol. VIII, 1861-62, p. 269.

FIGURE.

DISTRIBUTION. (a) *General*; — Cape Ann to Bay of Fundy.

(b) *In N. B. waters*; — "At Eastport, Me, in twenty fathoms, I have dredged several small specimens, about an inch in diameter, that appear to be referable to this species." Verrill (L).

This species is not at all common in our waters, but it possesses a special interest on account of the way it carries its young. The latter

are attached to the parent near the mouth by a cord or umbilicus and there they live until able to shift for themselves, the development being without a metamorphosis.

It has usually five rays, which are slender but not contracted at base. The ambulacral furrows are deep, the tube feet not forming four distinct rows. On the back, towards the disc, five longitudinal rows of spines may be distinguished, which become irregular towards the tips of the rays. The spines of both back and sides bear a small crown of minor pedicellariæ [i. e. the small pedunculated ones borne on the spines]. The madreporic plate is surrounded by a circle of spines and there are few or no major pedicellariæ. The papule or water-tubes of the back are placed singly and not in clusters as in *A. vulgaris*.

In color it is of a pale flesh color or white. It is about two and one-half inches in diameter. Nothing is known of its habits, and its development, as mentioned above, is direct.

[Prof. Verrill, in a letter to the writer, says :—" *A. compta*, St., I have from the Bay of Fundy, and I am inclined to think that *A. tensa* is only a slender variety of it." It is, however, left as a separate species in this paper, as Prof. Verrill has not published his comparisons of the two, and the writer has not been able to examine specimens of *A. compta*.]

[**Asterias (Leptasterias) Stimpsoni**, VERRILL (L).

DESCRIPTION. (L) p. 349.

LOCALITY. Eastport, Me., twenty fathoms, stony bottom, not common. Verrill (L).

Prof. Verrill now considers that this species was not well founded. He says, (S) :—"I have become satisfied that the species described by me as *A. Stimpsoni* in 1866, was not well founded. The study of a far more extensive series of specimens has shown that the specimens thus named were somewhat peculiar small specimens of *A. vulgaris* (Stimp.), with which some young specimens of *A. littoralis* were also confounded, so that the characters given largely appertain to the young of *A. vulgaris*."

12. **Stichaster albus**, (STIMPSON), VERRILL. *Asteracanthion albus*, St. (D). *Stephanasterias albula*, V. (N).
[See Plate, Fig. 6].

DESCRIPTION. (D) p. 14, (L) p. 351, (U) p. 29.

FIGURE. (D) pl. I., (U) pl. II.

DISTRIBUTION. (a) *General* :—Low-water to 192 fathoms. South of 40° N. lat., Eastport and Grand Manan, Davis

Strait, Franklin-Pierce Bay (North of Smith Sound), Iceland, Spitzbergen, Öfjord.

(b) *In N. B. waters*;—Grand Manan, four or five fathoms, among branching nullipores on east side of the islands, quite abundant, *Stimpson*, (D), "Eastport, Me., and Grand Manan, in ten to twenty fathoms, rocky bottoms, and among nullipores; also frequent at low-water of spring tides among rocks," *Verrill*, (L), (N).

This curious Starfish is not uncommon on our coast, and may be easily recognized when found. It has nearly always six rays (only about two per cent. having five), and three upon one side are usually much smaller than the three upon the other. It is generally quite small, not often exceeding one and one-half inches in diameter, though *Verrill* found a specimen at Eastport which was four inches across, and in a letter to the writer, he says he has since found it as large as six or eight inches across. The ambulacral furrows are very broad, and the tube-feet arranged in from two to four rows, according to age. The back and sides are covered with short spine clusters, which are so closely and regularly arranged as to give the animal a smooth appearance. Along the crest of each ray they are larger and more closely set than elsewhere so that there is a marked median line. There is a tuft of spines at the end of each ray.

In color it is faint red or cream color, *Stimpson's* many specimens being uniformly of the latter shade. It lives upon rocky bottoms, but nothing more is known of its habits, and nothing of its development.

Var. nitida.

[*Verrill* (L) established a new variety, *nitida*, from his large Eastport specimen, but that variety, he has since informed the writer, he now considers not well founded, his specimen being but a well developed individual of the species *albulus*]

FAMILY SOLASTERIDÆ.

With the cylindrical ambulacral feet arranged in two rows, the rays often more than five.

13. **Crossaster papposus**, (**Fabricius**), MÜLLER AND TROSCHEL. *Solaster papposa*, FORBES. (T), (D). [See Plate, Fig. 7.]

"Sun-Star."

DESCRIPTION. (A) p. 112, (T) p. 99, (U) p. 36.

FIGURE. (A) p. 112, (T) pl. XII., (U) pl. III.

DISTRIBUTION. (a) *General*;—Low-water mark to 610 fathoms. From Massachusetts Bay, northward to Smith Sound and all around the North Atlantic and Arctic Oceans to coasts of the British Islands and France, Spitzbergen and Barents Sea, and possibly Behring's Straits.

(b) *In N. B. waters*;—Grand Manan, rare and small on shelly bottoms in coralline zone, *Stimpson*, (D). Bay of Fundy, not uncommon, low water to forty-five fathoms, rocky bottoms, *Verrill*, (L). Eastport, low water to fifteen fathoms, *Verrill*, (N). Pendleton's Island, on reefs; L'Etang, fine specimens, stony bottoms, *Ganong*, (X). Bradelle Bank and deeper parts of Gulf of St. Lawrence, *Whiteaves*, (P).

This is one of the most beautiful and attractive of all our starfishes, being rivalled in these respects only by the "Cushion-Star," (*Goniaster Shapshiana phrygiana*). Its many regularly-radiating symmetrical rays, its pretty tufts of brush-like spines which cover its upper surface, and its always bright and often variable colors, are features which give it pre-eminence among its kindred.

It grows sometimes to a diameter of eleven inches, though it commonly is not more than from four to six. It may have any number of rays from ten to fifteen (though most frequently there are eleven, twelve or thirteen), each of which is flattened, tapers uniformly from base to tip and is equal in length to from one-half to the whole diameter of the disk. The ambulacral furrows are broad and contain two rows of tube-feet. The spinulation of this species is peculiar and very characteristic. The animal seems at first sight to be almost covered with tufts of slender spines, but a little study shows that they may all be referred to a few simple systems. All over the limestone network of the upper surface, both on arms and disk, are prominent club-shaped processes (running approximately in lines on the arms, but scattered irregularly on the disk), each of which bears on its summit a brush-like tuft or group of from eighteen to thirty slender articulated spinelets, which are about as long as the clusters are far apart. Upon the under surface, on each side of the ambulacral furrows, there occur two series of these clusters, both having all the spines of each single cluster in one plane. But the inner row, with its three to four spinelets to a cluster, has the plane of all the clusters parallel to the longitudinal axis of the furrow, while the outer row, having five to seven spinelets to a cluster, has the planes of these clusters at right angles to that axis. The inner series afford a protection to the furrow, being quite long enough to cover it when extended to meet from the two sides. The mouth plates, capping the inner angles where the rays meet, are large and sub-triangular

in form and each bears a marginal fringe of large strong spines, forming powerful mouth-papillae.

One of the most marked characters of the species is its always bright though often variable coloration, which varies with the sex. The fine specimens from L'Etang harbor are all a uniform brilliant red, which is said to be the case with those from Greenland. At other localities it occurs mottled with lighter shades, even to white and straw color, or of various shades of purple. Forbes tells us of specimens with the disk red, the arms white, tipped with red, and of another found by himself in which the body was red and the spiniferous tubercles bright green. Prof. Alexander Agassiz says that it sometimes has bands of red and purple arranged concentrically, and that there occur all shades between a brilliant red and a light orange or a dark violet. When young they are usually nearly white.

Crossaster lives always upon hard bottoms, in clear, cold water. It is said to be very voracious, living upon various molluscs, and to be occasionally injurious to oyster beds. Nothing whatever is known of its development.

14. ***Solaster endeca***, (GMELIN), FORBES. [See Plate, Fig. 8.]

"Purple Sun-Star."

DESCRIPTION. (A) p. 109, (T) p. 112, (U) p. 40.

FIGURE. (A) p. 109, (T) pl. XVII., (U) pl. III.

DISTRIBUTION. (a) *General*;—Low-water mark to ninety fathoms. Massachusetts Bay northward to Davis Strait and around the North Atlantic to the British Islands and France. Also Sitka and Alaska.

(b) *In N. B. waters*;—Grand Manan, abundant on rocks at low-water mark, small; large individuals, a foot in diameter, laminarian zone, *Stimpson*, (D). Bay of Fundy, low-water to twenty fathoms, *Verrill*, (L). Eastport, low-water to fifteen fathoms, *Verrill*, (N). Pendleton's Island reefs, and Bar Island at the mouth of L'Etang harbor, *Ganong*, (X). Gulf of St. Lawrence, *Whiteaves*, (P).

Upon our coast this Starfish is usually found in the same localities and very frequently associated with *Crossaster papposus*, though it prefers perhaps somewhat shallower water. At first sight it would seem to be closely allied to the latter species, and indeed was for a long time placed in the same genus with it, but a closer study shows that the two have little in common beyond the number of the rays. It is more

nearly related to *Cribrella sanguinolenta*, which, except for the difference in the number of the rays, it closely resembles.

It has been found even in our own waters as large as twelve inches in diameter, but most specimens would not much exceed half that size. It may have from seven to eleven rays, ten being perhaps the most common number. Each ray is nearly round in section, tapers evenly from base to tip, and is about as long as, or a little longer than the diameter of the disk. The ambulacral furrows, containing each two rows of tube-feet, are narrow and can be completely closed in by the bringing together of the edges of the furrow. The madreporic body lies about half way between the centre of the disk and an angle of the rays. The spinulation is not unlike that of *Cribrella* and differs considerably from that of *Crossaster*, in comparison with which it has quite a smooth appearance. The upper surface of both disk and rays is nearly covered with short blunt tubercles, each of which bear a crown of from five to ten short, rough, blunt spines, so small as to need a lens to properly distinguish them. These are scattered irregularly over the disk, but on the arms run in rather regular rows obliquely from the margin to the median line. On the under side are conspicuous rows of two kinds of spine-clusters, both of which kinds are flattened in a plane at right angles to the length of the ray. One of the rows, in which the clusters are made up of many slender, short spines united together at their bases, occupies all the outer margin of each ray, and curving evenly around the angle between any two contiguous ones shows no breaks between the marginal rows of the arms. This row therefore forms a band around the entire margin of the under side, with the exception of a minute break at the tip of each ray. A row of much smaller clusters follows this on its outer side throughout its course, but is upon the sides of the rays rather than on their under surfaces. The other conspicuous rows are those which start near the mouth and run along each side of each ambulacral furrow to the tips of the rays. The clusters are made up of much longer and stouter spines than the former row, some six or seven in number, united at their bases and placed all in one plane, which is as already stated at right angles to the length of the ray. Another row, consisting of a line of single spines, may be seen quite within the ambulacral furrow. The remainder of the under surface contains clusters of larger spines than those of the upper surface. The mouth plates are large and strong and bear several stout spines, which form powerful mouth-papillæ.

In color it varies much, though not to such a degree as *Crossaster* or *Cribrella*. Above it is usually some shade of purple or red, and below of a straw or cream color, and the color varies with the sex. In our waters the upper side is nearly always purplish red and the under light orange.

It lives upon rocky or other hard bottoms in clear water, and in its

habits seems to be much like *Crossaster*. Its development is entirely unknown, though from its relationship to *Cribrella* it is not improbable that it will be found to be viviparous.

15. ***Cribrella sanguinolenta***, (O. F. MÜLLER), LÜTKEN.
Linkia oculata, FORBES, (D). *Linkia pertusa*, (D). *Cribrella oculata*, (LINCK), FORBES, (U). [See Plate, Fig. 9.]
 "Eyed Cribrella."

DESCRIPTION. (A) p. 100, (K) p. 112, (T) p. 113, (U) p. 32.

FIGURE. (A) p. 100, (K) p. 112, (T) pl. XVIII., (U) pl. II.

DISTRIBUTION. (a) *General*;—Low-water mark to 194 fathoms. Long Island Sound to Waigat Strait on the West Coast of Greenland. Around the North Atlantic and Arctic Oceans to Great Britain and the English Channel. Spitzbergen, White Sea, Sea of Ochhotsk, Alaska.

(b) *In N. B. waters*;—Grand Manan, low-water mark to thirty fathoms on rocks, *Stimpson*, (D), *Verrill* (L). Eastport, low water to twenty-five fathoms, abundant, *Verrill*, (L), (N.) Bay of Fundy, low water to 100 fathoms, very common, *Verrill*, (Q). Shediac, on the oyster beds; deeper parts of Gulf of St. Lawrence, *Whiteaves*, (P). Abundant everywhere in the sheltered harbors of the southern coast.

This species cannot be mistaken for any other upon our coast. It is the only one of the five-rayed (not pentagonal) Starfishes which has but two rows of tube-feet to each ray—all others having four. Its smooth appearance and bright colors are also characteristic, and these features, together with its rather graceful form, make it a very pretty Starfish.

In size it varies greatly. Upon the shores at low water specimens occur of from the smallest size up to one inch in diameter. In deeper water they grow much larger. The largest of which the writer has been able to find any record is one found by Sars on the coast of Norway, which was a little over six and one-half inches in diameter, and another mentioned by Forbes, seven inches in diameter. But the writer has in his collection two specimens dredged in L'Etang harbor in the summer of 1886, one of which was ten and the other eight inches in diameter when alive; even in the dried state the former is a little over nine and the latter seven and one-half inches in diameter. Specimens five or six inches in diameter are not rare in our waters.

There are usually five rays, though very rarely six or seven-rayed forms may be met with. The proportional size of the length of the rays to the diameter of the disk varies greatly according to the size, and

therefore, in a general way, according to the age of the animal. In specimens less than one inch in diameter the length of the ray is less than twice the diameter of the disk. In a specimen four inches in diameter, the ray is nearly three times as long as the diameter of the disk, while in the very large specimens above mentioned it is nearly three and a half times. The rays taper evenly from base to tip, except in the breeding season, when they are enlarged at the base. The ambulacral furrows are narrow and can be completely closed in by the bringing together of their sides.

Its spinulation is quite simple. To the naked eye the whole of the upper and the most of the under surface present a uniformly granular appearance. A good lens, however, will show that these granules consist in reality of clusters of spines borne upon low tubercles. But the clusters vary greatly as to the number, shape and size of the spines on different parts of the surface of the body. Among the spine-clusters may be seen in dried specimens little holes, which in the living animals may be seen to be occupied, each by a delicate projection of a clear membrane from the interior of the body. These are the papulae or water-tubes, the function of which is not certainly known, but is supposed to be respiratory. It is the dotted or "eyed" appearance presented by these organs which is supposed to have suggested to Linck the name *oculata* which he gave to it and which is still used by some naturalists. Upon the under surface the spine-clusters grow somewhat larger as they approach the ambulacral furrows. Upon each side of the latter there runs from the mouth to the tip of the ray a row of clusters, flattened at right angles to the length of the ray, of very much larger spines; these spines are arranged in the cluster in a double row and are largest on the edge of the furrow, growing rapidly smaller away from it. Inside of this row, indeed quite within the furrow, is another row of apparently single spines. The mouth-plates are rather small and the spines they bear not appreciably larger than those along the ambulacral furrows.

In color *Cribrella* varies greatly, but is always bright. The under side is usually light yellow or straw colored, and the upper some shade of red or purple, or even yellow or orange. These colors, as in other Starfishes, are more or less due to differences of sex. In the case of the two large specimens above mentioned, found at L'Etang, the larger, which proved upon dissection to be a male, was a dull purplish red above, and the smaller, a female, a bright orange. Prof. Alexander Agassiz expresses the variation in this species very vividly when he says: "This pretty little Starfish presents the greatest variety of colors; some are dyed in Tyrian purple, others have a paler shade of the same hue, some are vermillion, others a bright orange or yellow. A glass dish filled with *Cribrellae* might vie with a tulip-bed in gayety and vividness of tints."

Our *Cribrella* lives upon the rocks and seaweeds about low-water mark, and on hard bottoms in deeper water. In moving, Prof. Agassiz points out (K) that it usually has three rays extended before it and drags the other two closely pressed together behind. In its development from the egg it passes through no free-swimming larval stage, but directly into the adult form. The young are carried about by the mother.

FAMILY ASTROPECTINIDÆ.

With the ambulacral feet conical, without suctorial disk, and arranged in two rows.

16. **Hippasteria phrygiana**, (PARELIUS), GRAY. *Goniaster equestris*, GMELIN, (A). *Goniaster phrygiana*, (D). [See Plate, Fig. 10.]

“Knotty Cushion-Star.” “Cushion-Star.”

DESCRIPTION. (A) p. 125, (K) p. 113.

FIGURE. (A) p. 125.

DISTRIBUTION. (a) *General*;—30 to 150 fathoms. Cape Cod northward to Arctic Ocean. Northern Europe and Great Britain.

(b) *In N. B. Waters*;—Grand Manan, off Duck Island in coralline zone, one specimen, *Stimpson*, (D).

This, says Stimpson, is “by far the most elegant of our Starfishes”; and Forbes calls it one of the most beautiful of the Starfishes of Britain. It is a pentagonal form and grows to be from nine to ten inches in diameter. The upper surface is covered with short, smooth spines, each of which is borne on the centre of a nearly circular plate. Around the margin of the upper surface there run two rows of plates which bear from one to three short spines. Along the ambulacral furrows are rows of spines arranged in pairs. In color it is generally bright red above and yellow beneath. Stimpson (D), thus describes his specimen:—“A large specimen was taken off Duck Island, in the coralline zone. It was bright red above, and bright yellow below, being by far the most elegant of our Starfishes. The minute vesicles which protrude from the dorsal pores are short and tipped with black. The eyes are very dark red in color, and the suckers near them are very long and slender, especially a single one just above each eye.”

Very little of its habits and nothing of its development are known.

17. **Ctenodiscus crispatus**, (RETZIUS), DÜBEN and KÖREN.
Ctenodiscus corniculatus, (LINCK), PERRIER, (U). [See
 Plate, Fig. 11.]

DESCRIPTION. (K) p. 113, (U) p. 49.

FIGURE. (K) p. 114, (U) pl. III.

DISTRIBUTION. (a) *General*.—Twenty-five to three hundred and twenty-one fathoms. South of Cape Cod, Bay of Fundy, Newfoundland, West coast of Greenland, Melville Island and Assistance Bay, Arctic Ocean, Spitzbergen, Barents Sea, Finmark, Scandinavian coast.

(b) *In N. B. waters*.—Grand Manan, fifty and sixty fathoms, muddy bottoms, not rare, *Stimpson*, (D). Beaver and Bliss harbors, mud bottoms, *Ganong* (X). Gulf of St. Lawrence, one of the most characteristic asterids of the greatest depths, *Whiteaves*, (P).

This is the most common of our three pentagonal Starfishes, and though dull in color is made attractive by its shape, curiously arranged marginal plates and unusual epinulation. In all of the pentagonal, as distinguished from the rayed Starfishes, the rays are much shorter than the diameter of the disk, and merge so gradually into it and into one another that the whole animal reminds one of a disk with five rounded lobes cut from its edge, rather than of a disk with five rays springing from it.

It sometimes attains to a size of over two and one-half inches across, but few specimens will exceed two inches. The rays are always five in number, about three-fourths of the diameter of the disk in length, and have the angles between them so well rounded that a very regular curve runs from the tip of each ray to the tip of its neighbor. The ambulacral furrows are rather broad, and each contain two rows of stout tube-feet, which, instead of being provided at their extremities with sucking disks, as in most of our Starfishes, are simply pointed. The upper surface of the disk, which in living specimens is usually swollen out, but in those which have been dried, very flat and somewhat depressed, is bounded all around by the upper ends of the marginal plates. It is almost completely covered by club-shaped processes or tubercles, each of which bears on its summit five to ten upright, rounded spines, so small as to be just visible to the naked eye. So uniform in size are these processes, with their flat tops and spine clusters, and so evenly and closely together are they placed, that their upper ends seem at first sight to form the upper surface itself of the animal. Near one angle is the madreporic body, and in the very centre of the disk is a conical pro-

jection, which is without function in the adult, but represents the remnant of the umbilical stalk by which the young are attached to the mother.

The marginal plates consist of two series, an upper and a lower. Each of the former is armed with a short, flattened spine, which points upwards. In the lower series, each plate is united with a corresponding one of the upper series, the line of junction being just above the row of flattened spines seen below the upper marginal row above described. Between each pair is a deep furrow which is continued on until it meets the ambulacral furrow, thus dividing up the under surface of the animal into bands which are seen to be covered with irregular scale-like plates. The ends of these bands, where they meet the ambulacral furrows, are formed by plates which bear each five or six short spines, the largest of which, about three in number, stand immediately on the margin of the ambulacral furrow, with the others behind them. The mouth plates are ovoid masses, bearing each nine mouth papillae and three to five nearly as large spines.

That this Starfish is low structurally, is shown by the fact that it, when adult, presents features which occur in the embryonic condition of other forms. The pentagonal form, pointed and suckerless tube feet, and structure of the spines are all of this nature.

In color it is dull, being usually of a light brownish or drab color, sometimes varying to dull brownish-red. The specimens taken in our waters seem to be of a dull greyish-brown. It seems to inhabit mud bottoms almost exclusively, and prefers considerable depths. Nothing further is known of its habits. Its development is direct, the young being attached by an umbilical stalk to the mother.

18. **Pteraster militaris**, (O. F. MÜLLER), MÜLLER and TROSCHEL. [See Figs. 12 and 12a].

DESCRIPTION. (U) p. 46.

FIGURE. (U) pl. III.

DISTRIBUTION. (a) *General*.—Twenty to one hundred and fifty fathoms. Bay of Fundy, northward to Smith Sound. Spitzbergen, Finmark, Norway.

(b) *In N. B. waters*.—Hake Bay, Grand Manan, thirty-five fathoms, shelly bottom, three specimens, *Stimpson*, (D). Eastport Harbor, west of Treat's Island, ten to fifteen fathoms; between Razor Island and Lubec, eight to ten fathoms, *Ferrill*, (N). Orphan Bank, somewhat plentiful, and deeper parts of Gulf of St. Lawrence. *Whiteaves*, (P).

This Starfish is one of the most interesting upon our coast, and unfortunately is not at all common. It is pentagonal in form, much arched above, and about two inches in diameter, though specimens four inches in diameter have been found. All around the outer lower edge of the rays runs a narrow fin-like web, and the whole upper surface is covered by a membranous skin which is supported upon the extremities of the spine clusters. This skin, therefore, covers the upper surface of the body as a tent with many poles covers the earth, and in the covered space thus formed the ova are protected and the young develop. Upon the under side there are peculiar spine-clusters along each side of the ambulacral furrows.

Connected to near their tips by a web or membrane are five or six long spines, lying all in one plane at right angles to the length of the ray, the outermost of which is much the largest. These large outer spines are connected together by and form the support of the web already mentioned, which runs all around the rays. In color it varies from brick red through flesh-color and yellowish white to pure white. Nothing is known of its habits, and there is still much to be learned about its development, though it is known that the young live in the pouch formed by the skin of the back, and develop without a metamorphosis.

[In addition to the above species Prof. Verrill tells the writer that he has from the Bay of Fundy, *Asterias compta*, St., a second species of *Pteraster* of small size, a small *Asterina*, and, he believes, *Solaster furcifer*, and probably others.]

Class III. ECHINOIDEA (SEA-URCHINS).

Spherical, heart-shaped, or disk-shaped Echinoderms with immovable skeleton, made up of calcareous plates, enclosing the body like a shell and carrying movable spines, and with locomotive and often respiratory ambulacral appendages.

Order I. CIDARIDEA (REGULAR SEA-URCHINS).

Echinoids with central mouth and equal band-like ambulacra.

FAMILY ECHINIDÆ.

With a round thin shell, broad ambulacral spaces bearing tubercles and spines, the pores grouped in transverse rows; oral branchiae present.

19. **Strongylocentrotus dröbachiensis**, (MÜLLER), A. AGASSIZ. *Echinus granulatus*, SAY, GOULD. (D). *Toxopneustes Dröbachiensis*, (K). *Eurychinus Dröbachiensis*.

sis, VERRILL. (L). *Euryechinus granulatus*, VERRILL. (L). *Echinus Drobachiensis*, MULL. (P). [See Plate, Fig. 13].

"Sea-Urchin," "Sea-Egg," etc.

DESCRIPTION. (K) p. 101, (O) p. 277, (U) p. 19.

FIGURE. (K) p. 102, (O) pl. X., (Q) pl. XXXV., (U) pl. II.

DISTRIBUTION. (a) *General*;—Littoral to 640 fathoms. Circumpolar. From Great Britain and Norway, all around the North Atlantic and down the American coast to New Jersey. North Pacific from Kamtchatka to Alaska and Vancouver Island.

(b) *In N. B. waters*;—Reported from St. Croix (now Dochet) Island in 1604 by Champlain. (*Voyages du Sieur de Champlain, Paris, 1613*). Grand Manan, low-water to half a fathom, very common. "In this zone, these animals are so crowded together that it is impossible in most places to thrust an oar to the bottom without striking some of them," *Stimpson*, (D). Eastport, littoral to twenty fathoms, very abundant, *Verrill*, (L), (N). Bay of Fundy, low water to 109 fathoms, very abundant, *Verrill*, (Q). Passamaquoddy Bay, very abundant, *Ganong*, (X). Shediac, Gulf of St. Lawrence, *Whiteaves*, (P.) Exceedingly abundant everywhere upon the southern coast. Up the St. Croix River as far as the Devil's Head. Manawanish Island, near St. John.

The common Sea-Urchin is the most abundant, best known and most easily recognized of all our Echinoderms. It cannot be confounded with any other animal upon our coast, though the writer has known it to be mistaken for a plant! In form it is somewhat hemispherical, with the flat side resting upon the ground, while the dead shell denuded of its spines may be likened in shape to an old-fashioned, smooth door-knob.

The largest specimens are four inches in diameter, including the spines, which are from one-half to three-fourths of an inch long. The latter, which are green in color, are attached to the shell by a ball and socket joint, and among them may be seen the ten meridional bands or zones of greatly extensible purplish tube-feet (each terminating in a sucking disk) which serve both for taking small prey and for locomotion. It can move but slowly and lives upon all sorts of bottoms, from mud to rock, from between tide marks down to considerable depths. It feeds upon both animal and vegetable food. With its five sharp teeth,

the tips of which can be seen in the centre of its under side, it browses or grazes, according to Sir William Dawson,* along the bottom upon confervoid sea weeds, diatoms, sponges, and even in places the garbage of the fisheries. It is quite variable, both in the form of the shell and the shape and color of the spines, the latter varying from violet even to dull white. The dead specimens so frequently found upon the shore, either cast up by the waves or carried up by the crows, show as perfectly as the most carefully prepared specimen the instructive and beautiful structure of the shell itself, and but little skill is needed to dissect out the internal organs.

Some Sea-Urchins have the power of excavating hollows in the solid rock, in which they live. It is not known how they do so. This is, however, not done by our species, though in exposed situations they may be found occupying any natural hollows or crannies. In the soft conglomerates of parts of Passamaquoddy Bay they are sometimes to be seen in hollows which at first sight appear to be excavated by them, but careful examination generally shows that the hollows are left by the falling out of large pebbles from the soft matrix. No. is our species of any great value as food, though this must be the species referred to by Dr. Stimpson (see p. 9 of this paper) as edible and as good as lobsters when boiled. A Mediterranean species is extensively eaten in Italy, and from being cooked by boiling and eaten from the shell as eggs often are, has given rise to its common name of Sea-Egg.

The course of its development from the egg is very well known. It has a larval stage (the Pluteus) which bears no resemblance to the adult. The larva has eight very long slender arms supported by calcareous rods, and a band of vibratile cilia, which assist it in swimming freely about. In about twenty-three days the Sea-Urchin begins to bud off from around the mouth of the larva, and as it grows the latter gradually disappears, being absorbed into the body of the adult.

Order II. CLYPEASTRIDEA (SHIELD-URCHINS).

Irregular Echinoids compressed to a shield form, with the mouth central and furnished with teeth; very broad ambulacra, a five-lobed ambulacral rosette upon the upper side; very small tube-feet.

FAMILY CLYPEASTRIDÆ

With the edge of the disk without deep indentations.

20. **Echinarachnius parma**, (LAMARCK), GRAY. *Echinarachnius Atlanticus*, GRAY (D). [See Plate, Fig. 14].

"Sand-Dollar," "Cake-Urchin."

DESCRIPTION. (K) p. 106, (O) p. 316.

* ("American Naturalist," I., 1867. p. 124.)

FIGURE. (K) p. 107, (O) pl. XIe, (Q) pl. XXXV.

DISTRIBUTION. (a) *General*; — Low-water mark to 888 fathoms. Almost cosmopolitan. Atlantic coast of North America from New Jersey to Labrador. Both sides of the Pacific Ocean. Australia, and possibly the Red Sea and India.

(b) *In N. B. waters*; — Grand Manan, low water on sandy shores, very common, *Stimpson*, (D); Eastport, low water, *Verrill*, (N); Chamcook harbor and Hospital Island, abundant, *Ganong*, (X); Shediac and Gulf of St. Lawrence, *Whiteaves* (P). Abundant on southern coast almost everywhere in sand just below low-water mark.

This Echinoderm is almost described, in so far as its general appearance is concerned, by its two English names alone. In outline it is nearly circular, is quite flat upon its lower side and only gently convex upon its upper, being in profile not unlike a strung bow. It grows to a diameter of three inches, is reddish brown in color and covered with crowded very short slender spines which make it appear, when first taken from the water, as if covered with velvet. The dead and bleached shells sometimes found upon the shore but easily prepared, show the plates of which it is made up and their homologies with those of the common sea-urchin, together with the distribution of the short ambulacral feet. The latter are confined upon the under side to five radiating furrows which branch towards the ends. Upon the upper side they are modified and enlarged to form branchial or gill-like appendages, and the pores through which they pass are arranged in a regular rosette of five petals, which is very conspicuous in the dead shell. The teeth are not visible externally, though they may be seen through the spines which protect the mouth.

The Cake-urchin lives always upon sandy bottoms and usually in shallow water. It creeps along very slowly by means of its many tube-feet just beneath the surface of the sand or half covered by it, feeding upon the minute organisms, both animal and vegetable, which the sand contains. It is itself eaten by some fishes, especially flounders. It has, according to Prof. Verrill (Q), a certain limited direct value to man. "The fishermen on the coast of Maine and New Brunswick sometimes prepare an indelible marking ink from these 'sand-dollars', by rubbing off the spines and skin, and, after pulverizing, making the mass into a thin paste with water." It is always an interesting form to all who chance to meet with it, on account of its shape and pretty markings.

In its development it passes through a metamorphosis similar to that of the ordinary sea-urchin, having a Pluteus not unlike the latter. [See Plate, Fig. 14a.] From a point near the mouth the adult sea-urchin buds off, gradually absorbing the substance of the Pluteus as it grows.

Order III. SPATANGIDEA. (HEART-URCHINS).

Irregular Echinoids more or less heart-shaped, with eccentric mouth, no teeth, and usually a four-leaved ambulacral rosette.

FAMILY SPATANGIDÆ.

21. *Schizaster fragilis*, (DÜBEN AND KOREN), AGASSIZ.

One of the "Heart-Urchins."

DESCRIPTION. (O) p. 363.

FIGURE. (O) pl. XXI.

DISTRIBUTION. (a) *General*;—80 to 321 fathoms. Straits of Florida, Bay of Fundy, Gulf of St. Lawrence, Lofoten Islands, Norway.

(b) *In N. B. waters*;—Centre of the Bay of Fundy, east of Grand Manan, 95 to 106 fathoms, *Verrill*, (R). Deep parts of Gulf of St. Lawrence, "widely distributed in the deep-sea mud," *Whiteaves*, (P).

This fine Sea-Urchin is a member of the Syrtensian and not of the Acadian Fauna, and is hence not likely to come into the hands of many of our collectors. It is the highest in organization of our Echinoids, a fact which impresses the observer at a first glance, for the radial symmetry is disguised so that its bilateral symmetry, showing a differentiation from the typical radiate towards a higher type, first strikes the eye.

In outline it is round heart-shaped, a little more than half as high as long. Large specimens are two and one-half inches in length, but the average is rather smaller. It is covered with short (one-eighth to one-fourth of an inch), slender brownish spines, which are largest about the branchial rosette. The latter is not regular as in the Cake-Urchin, the three anterior petals being much larger than the others. Running around the rosette and close to the tips of the petals is a line, the fasciole, which bears, not spines, but minute ciliated bristles. The mouth is not placed in the centre on the under side as in our other two forms, but near one end, where the shell forms a prominent lip to protect it. Owing to its eccentric position the ambulacral grooves radiating from it are of unequal lengths.

It lives chiefly upon muddy bottoms, but nothing further is known of its habits. There is some uncertainty about its development, but it is believed to pass through a metamorphosis somewhat similar to that of *Strongylocentrotus* with a free-swimming larva or Pluteus.

Class IV. HOLOTHUROIDEA (HOLOTHURIANS).

Worm-like, elongated Echinoderms, with a leathery body-wall, and contractile tentacles surrounding the mouth.

Order I. PEDATA.

Numerous ambulacral feet, sometimes arranged in the meridians and sometimes distributed over the whole surface.

FAMILY DENDROCHIROTÆ.

With tree-like branched tentacles, and the ambulacral feet arranged in regular rows, or confined to one side, which becomes a walking disk.

22. ***Psolus phantapus***, (STRUSSENFELDT), JAEGER. *Psolus laevigatus*, (C). [See Plate, Fig. 15.]

“Snail Sea-Cucumber.”

DESCRIPTION. (A) p. 203. (C) pp. 25, 36. (N) p. 342.

FIGURE. (A) p. 203.

DISTRIBUTION. (a) *General*.—Low water to eighty-six fathoms. Coast of Maine, Grand Manan and Greenland, and around the North Atlantic to Scandinavia and the British Isles.

(b) *In N. B. waters*.—Grand Manan, forty fathoms, common, attached to small stones; Eastport, one specimen, very large, from six inches deep in gravel, *Stimpson*, (D). Eastport, young, adult rare, *Verrill*, (N). Gulf of St. Lawrence, Orphan and Bradelle Banks, *Whiteaves*, (P).

This species resembles in a general way *Lophothuria Fabricii*, but presents characters by which it may readily be distinguished from it. It is of smaller size than the latter species, rarely, in our waters at least, attaining a length of three inches, though *Forbes* (A), says it grows to be six or eight inches in length. The flattened under side is quadrangular in outline and has three distinct and parallel bands, each of two rows, of large and strong tube feet, connected by a few scattering ones at the ends. The plates are arranged much as in *L. Fabricii*, but are much smoother, having few granules. Upon the upper side may be seen two longitudinal depressions of the skin and plates, representing the position of two rows of tube-feet. It is of a brownish color.

It lives in situations somewhat similar to *L. Fabricii*, but prefers in general deeper water, and is often found in the stomachs of fishes. But little is known of its habits, and nothing of its development.

23. **Lophothuria Fabricii**, (DÜBEN and KOREN), VERRILL.
Cuvieria Fabricii, DÜB. et KOR., (D). *Psolus Fabricii*,
 (D. and K.), LÜTKEN, (U).

"Sea-Orange." [See Plate, Figs. 16, 16 a.]

DESCRIPTION. (K) p. 98. (C) p. 35. (U) p. 10.

FIGURE. (K) p. 98. (U) pl. I. Emerton's "Life on the Sea-Shore," p. 137.

DISTRIBUTION. (a) *General*;—Low water to eleven hundred and sixty-eight fathoms. South of Cape Cod to Newfoundland and Greenland. Alaska. East of Nova Zembla (?)

(b) *In N. B. waters*;—Grand Manan, abundant but small, among nullepores in five fathoms; above low-water mark, under shelving rocks, very large, *Stimpson*, (D). Grand Manan, common in two to eight fathoms, in a few localities adhering firmly to rocks, *Verrill*, (L). Eastport, young common, adult rare, on ledges, *Verrill*, (N). Bar Island, Bliss Harbor, large and abundant, *Ganong*, (X). Gulf of St. Lawrence, near Percé and between Piclou Island and Cape Bear, P. E. I., *Whiteaves*, (P).

The common name by which the allied *Psolus phantapus* is sometimes known, the "Snail Sea-Cucumber," would apply equally well to and describe the appearance of this species also. At first sight it seems to have nothing in common with the Holothurians, resembling rather a large snail, or, even more closely, a huge nudibranch mollusc. In it, bilateral symmetry is prominent and completely disguises the radial. The animal is arched above, and flattened below to form a disk, the outline of which is oval in shape and sharply defined. Fig. 16a. Upon it are borne three bands of tube-feet (the other two being aborted and their places covered by the plates of the upper side), one band, four or five rows deep, following each long curve of the oval disk, and the third, almost aborted, but showing traces of its presence on the median line, on the long diameter of the disk. The entire dorsal surface is covered by large overlapping calcareous plates, each of which is covered with granules, and presents its rounded free edge towards the median line of the back. In the region of the apertures, however, they are arranged around the latter as centres. The tentacles can be greatly extended, even to the length of the body itself, are ten in number, very much branched, and supported upon a soft ring. When extended they are of extreme beauty, and comparable, as Mrs. Agassiz says, "for richness of tint, and delicate tracery, to the most beautiful sea-weeds," (K). The animal varies from two to four inches in length, and is always of a red color,

which varies from bright to dull brick-color. If placed in a glass vessel full of water, it will expand its tentacles and present a most beautiful sight. It lives among rocks at low and in shallow water, clinging to the under sides of ledges or in crevices between stones. In their development they pass through a free-swimming stage in which the bright red pear-shaped larva, having a circle of five tentacles at one end of the body and two at the other, moves by means of many cilia on different parts of the body. [See Plate, Fig. 166.]

24. **Thyonidium productum**, (AYRES), STIMPSON. *Duomodactyla producta*, (C).

DESCRIPTION. (C) p. 244.

FIGURE.

DISTRIBUTION. (a) *General*;—Bay of Fundy.

(b) *In N. B. waters*;—Eastport, rare, *Ayres*, (C); under stones at low water, not common, *Verrill*, (L); rare, (N). Grand Manan. "This species is found in deep water, but occurs most frequently under stones, or buried to a slight depth in gravel near low-water mark." *Stimpson*, (D).

This rather uncommon species may be readily distinguished when found, by the scattered tube feet, the latter being distributed without order over the greater part of the surface of the body. It is from three to five inches in length and lives under rocks or buried to a slight depth in gravel about low-water mark. *Ayres*' (C), description of it in part is as follows: "The *suckers* are numerous, without order. The neck, for about half an inch behind the base of the tentacles, is nearly naked. A few suckers, however, are found on it, larger than those on the other parts of the body. The integuments here, also, unlike those of the other parts of the body, contain an abundant calcareous deposit. The *tentacula* are of very unequal development; two large, ramose, then two very small (scarcely exceeding one-tenth of an inch), two again large, etc., thus making ten pairs. In *color* this species is of a pale yellow, the neck and tentacles being purplish." Nothing is known of its habits or development.

25. **Pentacta frondosa**, (GUNNERUS). JAEGER. *Cucumaria frondosa* (GUNN.), FORBES, (U). *Cucumaria fucicola*, FORBES and GOODSIR, (A). [See Plate, Fig. 17.]

"Sea-Cucumber," "Sea-Pumpkin."

DESCRIPTION (A) p. 209. (K) p. 99. (U) p. 2. (M) p. 347.

FIGURE. (A) p. 209. (K) p. 100. (U) pl. I.

DISTRIBUTION. (a) *General*;—Low water to one hundred and forty-one fathoms. South of Cape Cod to Greenland and Assistance Bay, (lat 74° N.); around the North Atlantic to Scandinavian coast and British Islands, Spitzbergen. Alaska?

(b) *In N. B. waters*;—Grand Manan. "Nothing can exceed the profusion in which this species exists in some parts of the islands. It is found just below the ordinary low-water mark on rocky shores, and is, therefore, exposed at spring tides. I have seen areas of several square rods entirely occupied by them."—*Stimpson*, (D). Eastport, twenty fathoms, stony bottom, abundant, *Verrill*, (L); on the shores to fifteen fathoms, (N). Passamaquoddy Bay, L'Etang Harbor, very large, *Ganong*, (X). Gulf of St. Lawrence, *Whiteaves*, (P). Very abundant everywhere in the harbors of the southern coast.

This is one of the most abundant shore animals upon our southern coast. It is a good typical Holothurian, and affords a most excellent subject for dissection and study.

Its shape is quite well described by its name of sea-cucumber, or even better, of sea-pumpkin. When out of the water and in a contracted state, it is of an ellipsoidal, sometimes nearly spherical form; but when alive and undisturbed in the water it may take any one of several shapes, from long and slender cylindrical to short and rounded or even dumb-bell form. Large specimens, which are a foot long, have the power of extending themselves to two or three times that length. In cross section the animal is somewhat pentagonal in form, and at each of the angles is a band of tube-feet running nearly the entire length of the body, consisting of two rows, the individual members of one row alternating with those of the other. The skin is very tough and wrinkled and of a dark reddish or purplish brown or chocolate color on the upper side, shading to grey, flesh-color, or even white, on the side in contact with the bottom. The tentacles, which the animal may be seen to protrude when placed in a dish of water, or when undisturbed in some pool, are ten in number, much branched, and very graceful when fully expanded.

This species lives about and just below low-water mark, preferring hard bottoms and clear water. It can move but slowly and captures its food, consisting chiefly of small animals, by means of its tentacles. In its development it passes through a metamorphosis in which the fully-grown larva (*Auricularia*) is of a red color, cylindrical, with a few constrictions or annulations and four or five bands of cilia by means of which it can swim freely about.

It has already been pointed out in Section I. of this paper (p. 9) that this species is edible. Some further investigations into its value for food are much needed.

26. **Pentacta minuta**, (LÜTKEN), VERRILL. *Cucumaria minuta*, (FABR.), (M). *Ocnus Ayresii*, ST., (D). *Cucumaria frondosa* (GUNN.) FORBES, (U), [Young.]

DESCRIPTION. (D) p. 16.

FIGURE.

DISTRIBUTION. (a) *General*;—Sixty to one hundred and one fathoms. Maine, northward, and North European seas.

(b) *In N. B. waters*;—Grand Manan, "dredged on shelly bottoms, in twenty-five fathoms," Stimpson, (D).

There is some doubt as to whether this is a distinct species, or only the young of *P. frondosa*. Duncan and Sladen in their splendid memoir (U), hold to the latter view; Prof. Verrill, (L), (W), and others, believe the former. It is introduced here as a distinct species, on the authority of Prof. Verrill, who has had better opportunities to study it than others have had.

Following is Stimpson's description of the species, (D): "Completely encased in calcareous matter in the form of polygonal plates somewhat variable in size, but usually equalling in area one-half that of the disk of the sucker. These plates have regular and equal perforations in quincunx, smaller in width than their interspaces. The suckers are stout, and are distributed distantly in five rows, in the three ventral of which they are much larger than in the two dorsal. There are about seven suckers in each row, which are encased in the calcareous plates on their sides. The tentacula are short, and have few blunt branches. The color is white, or pale fawn. Length usually two-tenths of an inch; breadth 0.15 inch." Nothing is known of its habits or development.

Order II. APODA.

No ambulatory feet, usually no respiratory tree, and the tentacles usually branched or pinnate.

FAMILY SYNAPTIDÆ.

Hermaphrodite and without respiratory trees. With symmetrical calcareous bodies in the skin.

27. **Caudina arenata**, (GOULD), STIMPSON. [See Plate, Fig. 18.]

DESCRIPTION. (C) p. 143. (M) p. 358.

FIGURE. (K) p. 97. (M) pl. XX.

DISTRIBUTION. (a) *General*;—East Coast of America, Vineyard Sound to Massachusetts Bay and Gulf of St. Lawrence.

(b) *In N. B. waters*;—Point du Chêne, N. B., at low water, *Whiteaves*, (P).

[Selenka, (M), gives as a locality for this species, Grand Manan. But he was probably led into error by the fact that Stimpson mentions this species in his Synopsis in order to refer it to the new genus *Caudina*. Stimpson distinctly states that "it does not occur in the Bay of Fundy, notwithstanding its abundance on every sandy shore in Massachusetts Bay." Verrill says, (Q), he has never been able to find it at Grand Manan.]

This species is not likely to be mistaken for any other upon the Gulf coast, the peculiarity indicated by its generic name distinguishing it from all others. It is from two to four inches long, and over one-third of this length is so attenuated as to seem in comparison with the rest of the body like a "tail." When alive it is very worm-like in appearance, having no tube-feet, being semi-translucent and having a perfectly flexible skin. It shows, however, the stamp of the pentamerous Echinoderm plan in the five longitudinal lines which may be traced from end to end of the body, the representatives of the lines of ambulacral tube-feet. Around the mouth are about twelve short, non-retractile tentacles, each divided near the extremity into several slender branches. The skin has a finely granular appearance, caused, as the microscope will show, by the immense number of little calcareous, wheel like plates embedded in it. In color it varies from red to flesh-color.

Caudina lives buried a short distance in sand or mud in shallow water and is often thrown upon the sandy beaches of Massachusetts Bay in great numbers after a storm, and probably the same would be true upon our north shore. Little is known of its habits and nothing of its development.

28. **Chirodota laevis**, (FABRICIUS), GRUBE. *Trochinus pallidus*, (C), [See Plate, Fig. 19.]

DESCRIPTION. (C) p. 243. (U) p. 12.

FIGURE. (U) pl. I.

DISTRIBUTION, (a) *General*;—Circumpolar. Eastport to Greenland. Finmark and Lofoten, and possibly Ochotsk Sea and Sitcha.

(b) *In N. B. waters*:—Grand Manan, low water to four or five fathoms, *Stimpson*, (D). Eastport and Grand Manan, under stones at low water, common, *Verrill*, (L), (N). Devil's Head, St. Croix River, plenty, *Fuller*, (H). Craig's Ledges, Passamaquoddy Bay, lowest tides, abundant [under name *Synapta tenuis*], *Ganong*, (X). Gulf of St. Lawrence, *Whitcaves*, (P).

This Holothurian is very worm-like in appearance, with its long cylindrical body entirely free from suckers or other appendages. When alive it is transparent enough to show the internal organs and the five longitudinal rows of muscles. In the spaces between these rows are scattered little excrescences which are sometimes one twenty-fifth of an inch in diameter, and which under the microscope may be seen to be made up of a great number of little spicules in the form of beautiful and regular six-spoked wheels. There are twelve tentacles, each consisting of a base and ten to twelve branches or fingers. The animal rarely exceeds four inches in length. It is of a pale flesh-color when alive, and even in alcohol does not lose altogether its translucency.

As to its habits, *Stimpson* says: "This species is fully and well described by *Otho Fabricius*, and his account of its habits applies precisely to those of our species, as I have often observed at Grand Manan. It lives in the stony mud of the shores of these islands, buried to a depth of a few inches, usually in a horizontal position. It is found at low water, but is most abundant at a depth of four or five fathoms." Nothing is known of its development.

[*Prof. Verrill* tells the writer that in addition to those of the above list, he has from the Bay of Fundy two species of *Trochostoma* (formerly *Molpadia*), *Synapta*, one or two more species of *Thyonidium*, *Thyone scabra*, and probably others. These will be described in one of his coming reports].

IV. SUPPLEMENTARY LISTS.

1. List of Species of Echinodermata dredged by Mr. Whiteaves, (P), in the deeper parts of the Gulf of St. Lawrence, but not yet reported from the Bay of Fundy.

Ophiuroidea.

Astrophyton eucnemis, Mull. and Trosch.
Amphiura Holbollii, Lutken.
Ophioglypha nodosa, Lutken.
Ophioglypha Stuwitzii, [*vide* Verrill, (W).]
Ophioscolex glacialis, Mull. and Tr.
Ophiopeltis, near *O. borealis*, Sars.

Asteroidea.

Asterias polaris, Mull. and Trosch.
 ? *Pedicellaster paleocrystallus*, Sladen. [*vide* Verrill, (W).]
Pedicellaster typicus, [*vide* Verrill, "Am. Jour. Sci."
 xvi., 214.]

Holothuroidea.

Pentacta calcigera, Stimps.
Eupyrus scaber, Lutken.
Eupyrus, nov. sp., *vide* Verrill.
Myriotrochus Rinkii, Steenstrup.
Oligotrochus vitreus, Sars. [*vide* Whiteaves MS.]
Molpadia turgida, Verrill. [*vide* Verrill, "Am.
 Jour. Sci." xvii., 473.]

2. List of Species found by Mr. Whiteaves, (P), upon Orphan and Bradelle Banks, those shallow water outliers of the Syrtensian fauna of the deeper parts of the Gulf.

(a) On Orphan Bank.

Pteraster militaris.
Asterias grœnlandicus.
Psolus phantapus.

(b) On Bradelle Banks.

Astrophyton Agassizii.
Ophioglypha Sarsii.
Ophioglypha nodosa.
Psolus phantapus.
Ophiocoma nigra.

3. List of Species dredged by Mr. Whiteaves in the shallow southern basin of the Gulf, but not found within the limits of this paper.

Cucumaria pentactes, O. F. Muller,
Molpadia oolitica, Pourtales. } [*fide* Whiteaves MS]
Eupyrgus scaber, Lutken.

V. THE COLLECTION AND PRESERVATION OF ECHINODERMATA.

Like other animals, and, indeed, like all natural objects, Echinoderms can only be studied from specimens. As far as possible, they should be observed in their own homes and under their natural conditions of life. But this is not enough; they must be taken away to where their anatomy can be studied at leisure and under more favorable conditions, and to serve to illustrate to others, and to arouse in them an interest in, these forms. How to collect, and, particularly, how to preserve Echinoderms, must therefore be an important part of our consideration of the group.

There are two methods of taking them, shore-collecting and dredging. The best localities for both are found where strong but not violent currents of the clearest water flow over bottoms of various kinds, but with rock and gravel predominating. For shore-collecting those places are particularly good where the tide leaves among the ledges pools with bottoms of gravel and scattered boulders. To such places the student should go at the time of the spring tides if possible, for the greater retreat of the water will lay bare many a treasure inaccessible at other times. He should go clad in his oldest clothes and long rubber boots, carrying with him one or two ordinary pails, some small bottles or vials of alcohol in his pockets, and a spade for digging in the gravel, the handle of which can be used as a lever for overturning stones. A companion to act as general assistant will be found of great value. Then, looking upon the less exposed open places, peering under ledges and among boulders, searching among the seaweeds, digging in the gravel, overturning stones and scanning their under sides, the student, if his heart be in his work, cannot fail of a rich harvest.

But many species live always below low-water mark, and to take such a dredge is required. The latter may be of the same pattern for all depths. It consists essentially of an iron frame, about eighteen inches long by six broad; the long sides are scraping jaws of thin flat iron, somewhat diverging; the short sides are simply round bars connecting the scraping pieces. From the sides slender bars run convergingly forwards for the attachment of the rope, and behind drags the bag (made of *very* coarse canvas, or, better, fine netting), which is to catch all that is loosened by the scraping jaws.* The dredge is to be dragged behind a sail boat, and the student will learn in a surprisingly short time all the proper methods, places, precautions, difficulties, pleasures and uses of dredging, which it would take many pages to set forth here.

There are two principal ways of preserving Echinoderms, dry or in a preserving fluid. The first method is much the less expensive and in many ways the more convenient, but is not suited for specimens which are to be used for the study of the internal organs or other soft parts. The only preservative fluid of value is alcohol, the ordinary spirits of wine of the druggists. Methyl alcohol or methylated spirits, which is cheaper, may be used for temporary storage and the like, but it is not so well suited for permanent preservation of valuable specimens. But no specimen should be plunged directly into the strong alcohol from water, for great shrinkage would result. They should be placed first in alcohol which has been diluted with nearly its own bulk of fresh water, left three or four hours and then be transferred to the stronger grade. Bottles with ground glass stoppers should be used for the permanent preservation of alcoholic material, as they reduce to a minimum the amount of evaporation.

For preserving specimens dry it is only necessary to fix in some way the tissues so that the animal will keep its shape, and then to dry it, preferably by artificial heat. A few Echinoderms do not need this preliminary fixing but may be dried at once.

*The limits of our space will not allow of a full description of the dredge or dredging; such may be found in almost any work on seashore animals, such for instance as J. H. Emerton's "Life on the Seashore," [Salem, Bates.]

CRINOIDS. The Crinoids may be simply dried in the sun or by artificial heat, but being fragile are best preserved in alcohol. One can well afford the alcohol for a Crinoid.

OPHIURANS. So abundant are the hard parts in this group that if the internal anatomy be not needed, they may simply be dried, preferably by artificial heat. Better results are obtained by the method described below for Starfishes.

STARFISHES. Some Starfishes will keep their shape when simply dried in the sun, but most of them will expel water and collapse under this treatment. But if their tissues be hardened before the drying this will not happen. This can best be done by taking them very quickly from a glass vessel of water in which they are alive and expanded, and plunging them suddenly into a vessel containing enough alcohol of any grade between forty and sixty per cent to cover them. In this they should be allowed to remain about half an hour, when they should be taken out and dried by artificial heat. This may be best done by placing them some distance above a stove upon a piece of cloth supported by a wooden frame. In this way the form and, to a great extent the color, of Starfishes may be beautifully preserved. Of course the alcohol can be used for this purpose over and over again. There can be substituted for the use of the alcohol in this method, fresh water heated nearly to boiling, in which the specimens are to be plunged for a few seconds only and then dried as above directed.

SEA-URCHINS. These may be treated as recommended for Starfishes, particularly when it is wished to retain the spines. If simply the shell is wanted, the animal should be boiled for a few minutes in a weak solution of caustic potash, when all animal matter can be easily washed away.

HOLOTHURIANS. These can be well preserved only in alcohol,

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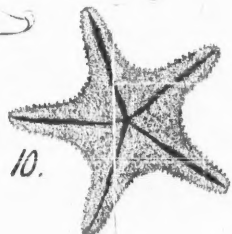
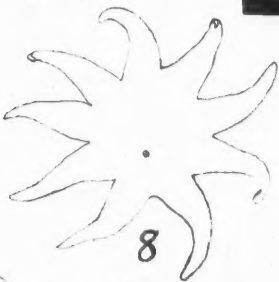
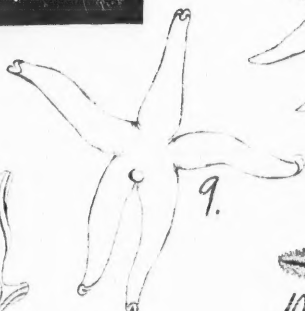
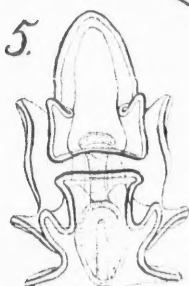
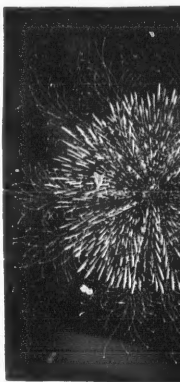
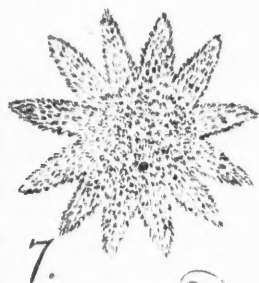
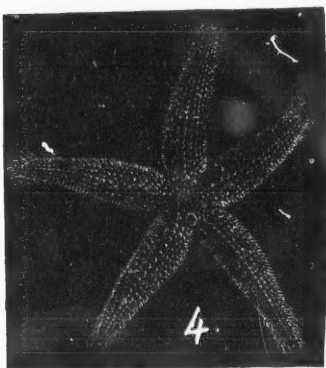
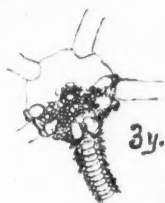
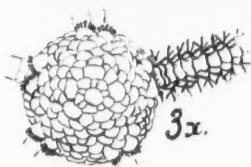
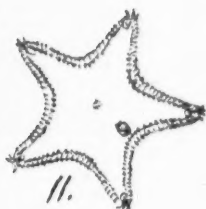
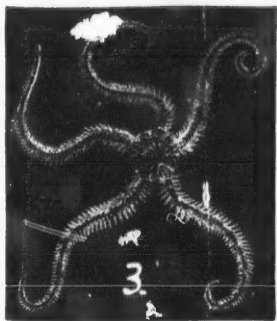
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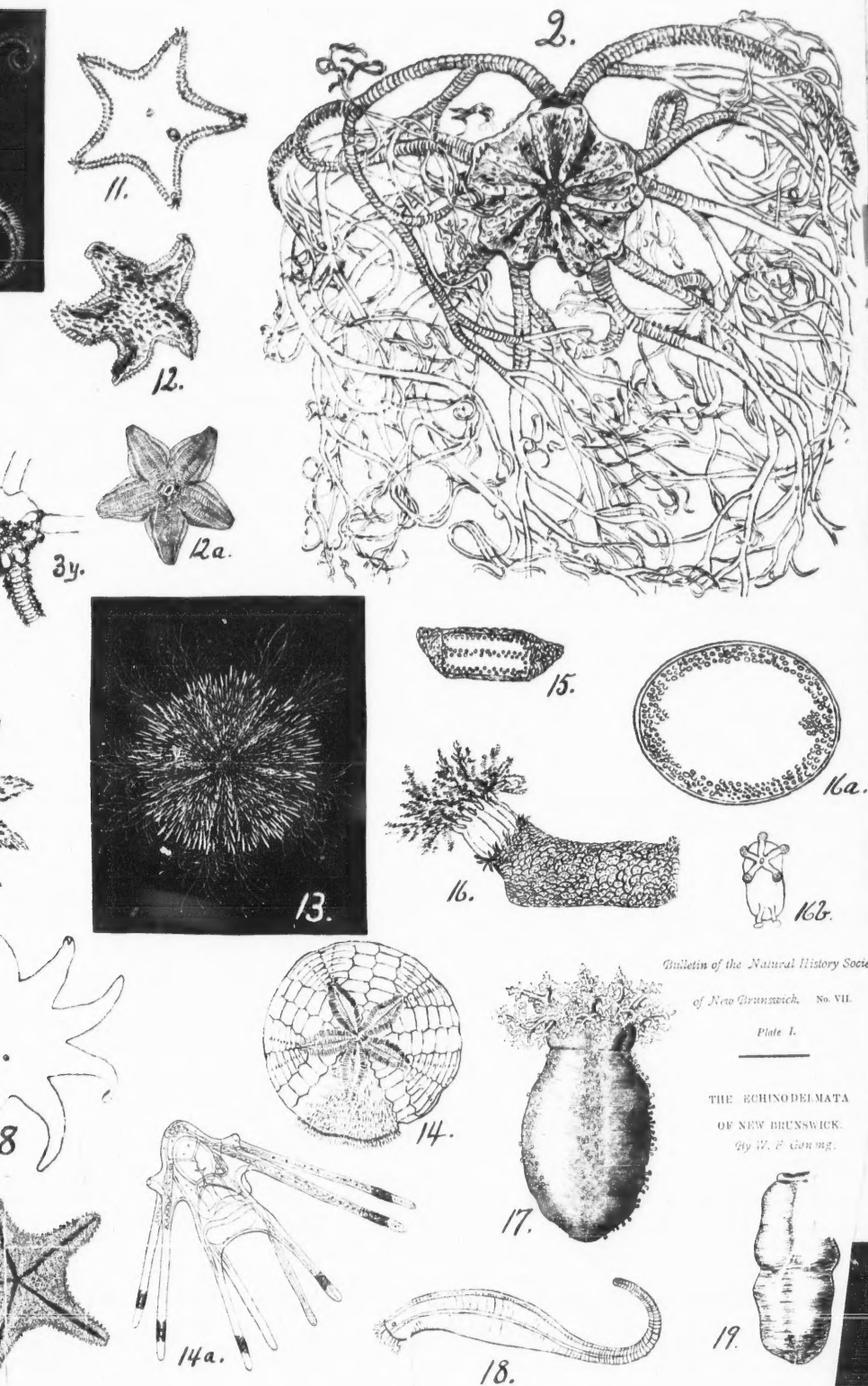
VII.

EXPLANATION OF PLATE.

- FIG. 1. *Antedon Eschrichtii*. After *Duncan and Sladen*, (U). One-half natural size.
- FIG. 2. *Gorgonocephalus Agassizii*. After *Duncan and Sladen*, (U). One-half natural size.
- FIG. 3. *Ophiopholis aculeata*. After *Agassiz*, (K). One-half natural size.
- FIG. 3x. *Ophioglypha robusta*. After *Duncan and Sladen*, (U). Three times natural size.
- FIG. 3y. *Ophioglypha Sarsii*. After *Duncan and Sladen*, (U). One-half natural size.
- FIG. 4. *Asterias Forbesii*. After *A. Agassiz*, (K). One-half natural size.
- FIG. 5. *Brachiolaria* of *Asterias Forbesii*. After *E. B. Wilson*. From *W. K. Brooks' "Handbook of Invertebrate Zoology."* Greatly magnified.
- FIG. 6. *Stichaster albulus*. After *Stimpson*, (D). Natural size.
- FIG. 7. *Crossaster papposus*. After *Forbes*, (A). One-fourth natural size.
- FIG. 8. *Solaster endeca*. After *Forbes*, (A). One-fourth natural size.
- FIG. 9. *Cribrella sanguinolenta*. After *A. Agassiz*, (K). Natural size.
- FIG. 10. *Hippasteria phrygiana*. After *Verrill*. Report U. S. Fish Commission for 1883. One-fourth natural size.
- FIG. 11. *Ctenodiscus crispatus*. After *A. Agassiz*, (K). One-half natural size.
- FIG. 12. *Pteraster militaris*. Upper surface. After *Duncan and Sladen*, (U). One-half natural size.
- FIG. 12A. *P. militaris*. Under surface. After *Sars*. Copied by *Verrill*. Report U. S. Fish Commission for 1883. One-half natural size.
- FIG. 13. *Strongylocentrotus dröbachiensis*. After *A. Agassiz*, (K). One-half natural size.
- FIG. 14. *Echinarachnius parma*. After *A. Agassiz*, (K). One-half natural size.
- FIG. 14A. *Pluteus* of *E. parma*. After *J. W. Fewkes*, *Bulletin Museum Comparative Zoology*, Vol. XII, No. 4. Greatly magnified.
- FIG. 15. *Psolus phantapus*. Under side. After *Forbes*, (A). One-half natural size.
- FIG. 16. *Lophothuria Fabricii*. After *A. Agassiz*, (K). One-half natural size.
- FIG. 16A. *L. Fabricii*, under side. After *Duncan and Sladen*, (U). One-half natural size.
- FIG. 16B. Larva of *L. Fabricii*. After *J. H. Emerton*, "Life on the Seashore." Greatly magnified.
- FIG. 17. *Pentacta frondosa*. After *J. H. Emerton*, "Life on the Seashore." One-fourth natural size.
- FIG. 18. *Caudina arenata*. After *A. Agassiz*, (K). One-half natural size.
- FIG. 19. *Chirodota laevis*. After *Duncan and Sladen*, (U). Natural size.







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Plate I.

THE ECHINODERMATA

OF NEW BRUNSWICK.

By W. F. GUNN.